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#206 JULY 2022

Sky at Night

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The story behind the first image of the Milky Way's central black hole

21 TOP SUMMER TARGETS FOR URBAN ASTRONOMERS

THE ROSWELL INCIDENT AT 75: WHERE ARE ALL THE ALIENS?

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Welcome

A remarkable image from a camera the size of a planet

The image of Sagittarius A*, the supermassive black hole at the centre of the our Galaxy, produced using the Event Horizon Telescope, is astounding. Five years in the making, and taken with a 'camera' the size of Earth; it's the result of collaboration between 80 institutions and more than 300 scientists. It is the first direct visual proof that our theories are correct, and there really is an immense gravitational engine driving our Galaxy. Astronomy writer Jane Green explores the story behind the image on page 67.

Sagittarius A* may be out of reach for us amateur astronomers, but the summer skies are full of deep-sky targets for observers and imagers with telescopes – even from towns and cities, if you know where to look. Someone who does is American amateur astronomer Rod Mollise, and on page 28 he continues his series with 21 summer deep-sky targets, all visible with some degree of skyglow.

You'll want to observe these deep-sky delights at the start and end of July, avoiding the week or so around the 13th, when it's full Moon and bright moonlight will wash the sky. This full Moon is a noteworthy one, though – the largest perigee full Moon of the year and so the closest to Earth. While this only increases its apparent size by a few arcminutes, what will make far more of an impression is the Moon illusion, that powerful trick of the eye when the Moon is close to the horizon and appears much bigger than normal. Moonrise is at 21:11 BST on the 13th – do look out for it.

Enjoy the issue!

Chris Bramley, Editor

PS Our next issue goes on sale on Thursday 14 July.

HOW TO CONTACT US

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Editorial enquiries +44 (0)117 300 8754
9:30am–5:30pm, Mon–Fri
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Editorial enquiries
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(an Immediate Group Company), Eagle House,
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Sky at Night – lots of ways to enjoy the night sky...

Television
Find out what *The Sky at Night* team have been exploring in recent and past episodes on page 18

Online
Visit our website for competitions, astrophoto galleries, observing guides and more

Social media
Follow us on Twitter, Facebook and Instagram for space news, astro images and website updates

Podcasts
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Get each month's issue on your Apple or Android device, now with bonus image galleries

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The best targets to observe each week, delivered to your inbox. Visit **bit.ly/skynewsletter**

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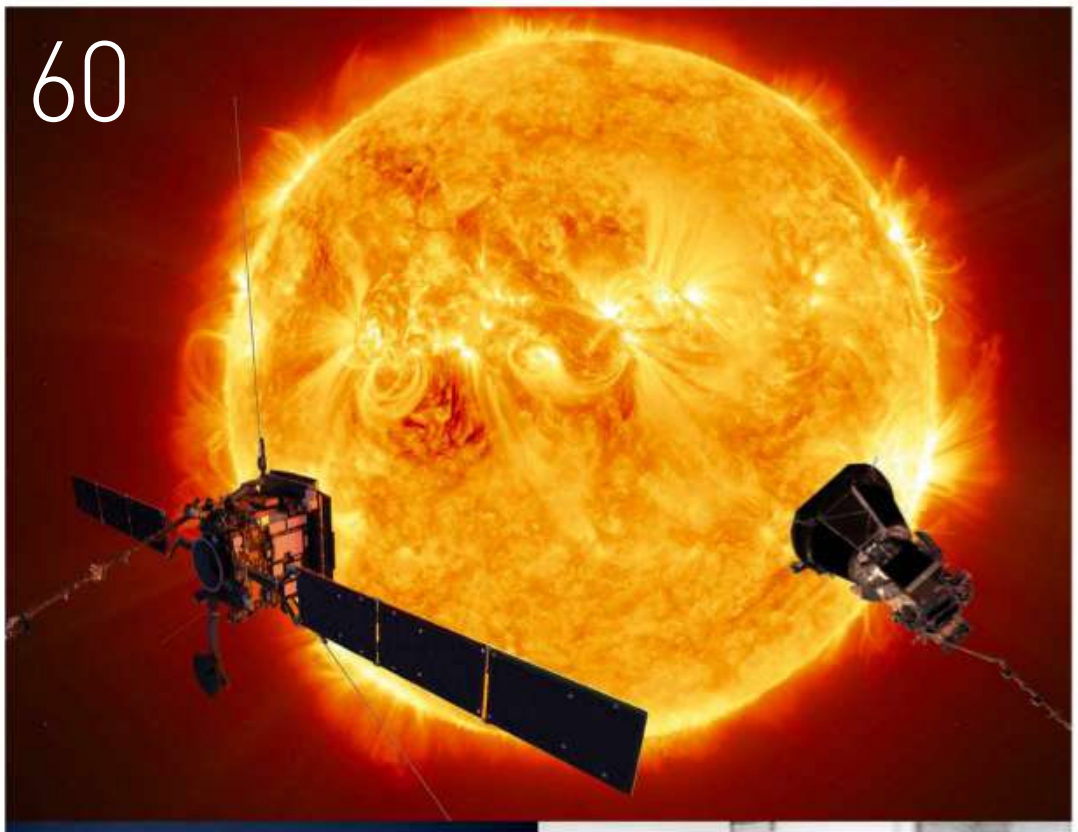
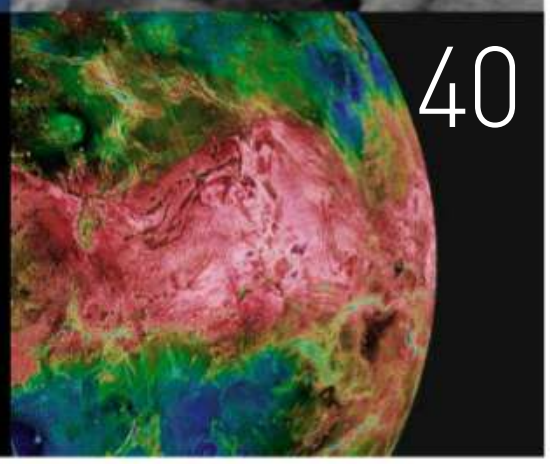
COVER IMAGE: ESO/ESA/HUBBLE/M. KORNMESSER. THIS PAGE: M-GUCCI/ISTOCK/GETTY IMAGES, SOLAR ORBITER: ESA/ATG MEDIALAB; PARKER SOLAR PROBE: NASA/JOHNS HOPKINS APL, @THESHED_PHOTOSTUDIO, US GOVERNMENT, EHT COLLABPRATION, MAGELLAN TEAM/JPL/USGS, FRANCK MARCHIS/SETI, BBC, MARK PARRISH

New to astronomy?

To get started, check out our guides and glossary at **www.skyatnightmagazine.com/astronomy-for-beginners**





This month's contributors

Nick Pope

UFO expert

"Amid de-classified files and an increase in 'UFO' sightings, it's the perfect time to explore what actually happened at Roswell." **Nick marks the 75th anniversary of ufology's most famous case,** **page 34**

Paul G. Abel

Astronomer

"Venus's Ashen Light has been reported by observers for centuries, and now the Parker Solar Probe may have seen definitive proof of it." **A strange glow on the surface of Venus might be real. Paul investigates,** **page 40**

Jane Green

Astronomy writer

"It was thrilling to delve into the EHT project and see our backyard black hole for the very first time!" **Jane chronicles the five-year project to image our Galaxy's central black hole, starting on** **page 67**

Extra content ONLINE

Visit **www.skyatnightmagazine.com/bonus-content/TUYY8NE/** to access this month's selection of exclusive Bonus Content

JULY HIGHLIGHTS

Interview: Searching for intelligent life

The SETI Institute's Franck Marchis talks astrobiology, exoplanets and what he really thinks about UFOs.

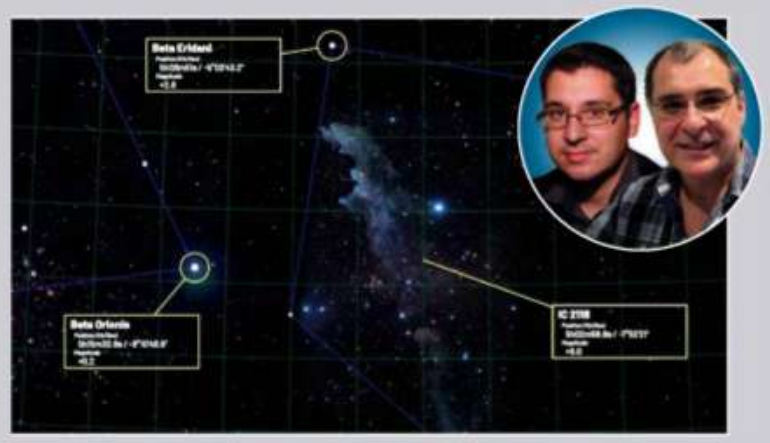
Watch The Sky at Night *Destination Moon*

The team look back at the Apollo missions and discover how space agencies are preparing to return to the Moon.

DIY Astronomy: Build a webcamscope

Download plans and images to help you complete this month's DIY Astronomy project (see p74 for more info).

The Virtual Planetarium



Pete Lawrence and Paul Abel guide us through the best sights to see in the night sky this month.

A DATE WITH DESTINY

A tiny dwarf galaxy is inexorably drawn into the grasp of a double-ringed giant in this spectacular new portrait

VÍCTOR M BLANCO 4-METRE TELESCOPE, 3 MAY 2022

Locked in a tango across an ink-black dancefloor and against a twinkling background of thousands of other objects, are two galaxies in the southern constellation of Horologium, the Clock.

The vast galaxy on the left, a magnificent barred spiral, is NGC 1512. At 70,000 lightyears across it almost rivals our own Galaxy for size. At its heart is a stunning 2,400-lightyear-wide ring strewn with infant star clusters, called a circumnuclear starburst ring.

Snaking far, far out into space are its huge arms, gleaming with countless hot, blue stars. Falling into their grasp is the dwarf lenticular galaxy NGC 1510. This tiny neighbour also glows with new star formation, triggered by its endless gravitational tussles with its bigger partner. Eventually, in several million years, the diminutive galaxy will be engulfed.

The pair were captured by the state-of-the art widefield Dark Energy Camera on board the Víctor M Blanco 4-metre Telescope in northern Chile.

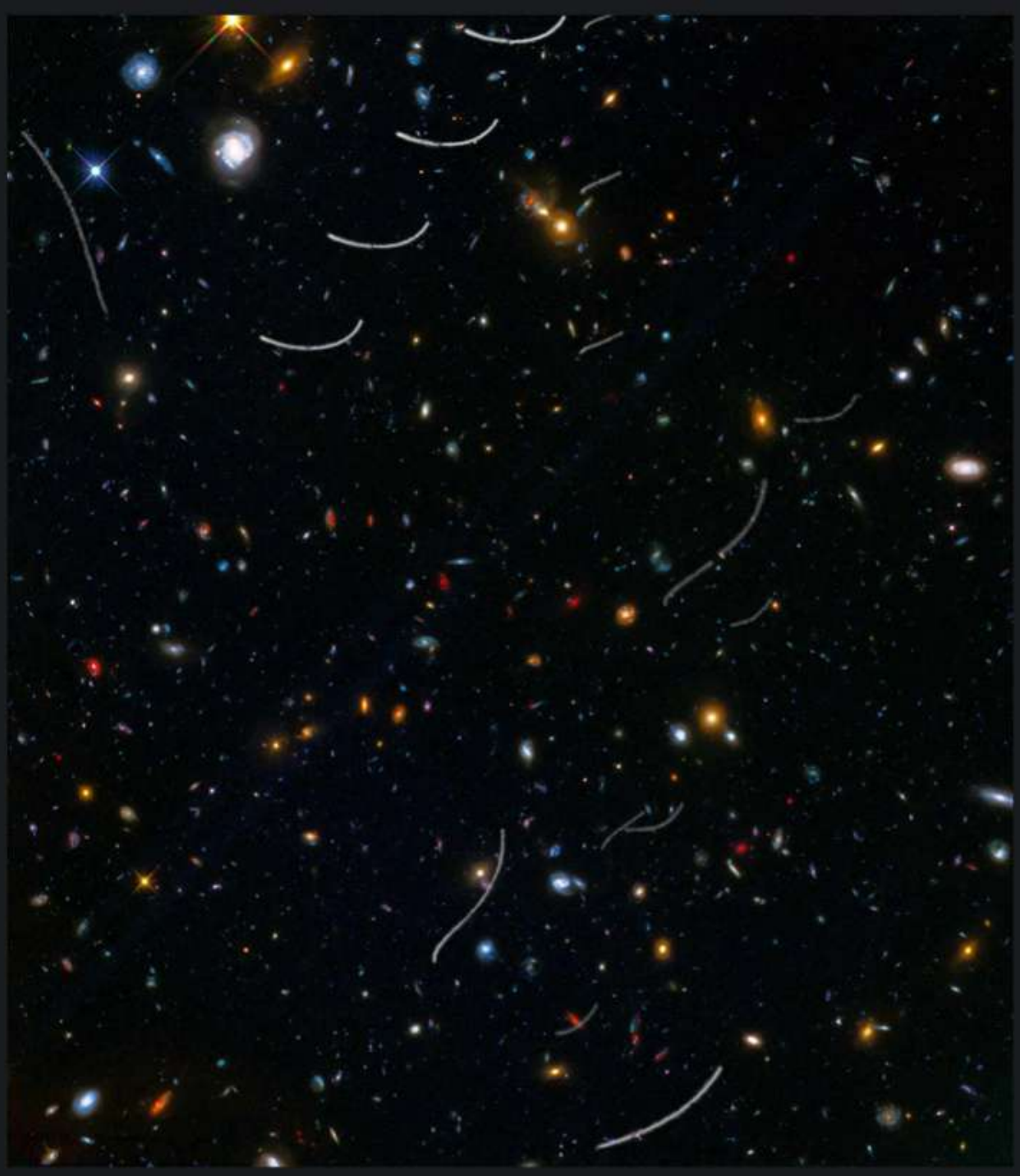
DARK ENERGY SURVEY/DOE/FNAL/DECAM/CTIO/NOIRLAB/NSF/AURA
IMAGE PROCESSING: T.A. RECTOR (UNIVERSITY OF ALASKA ANCHORAGE/NSF'S NOIRLAB), J. MILLER (GEMINI OBSERVATORY/NSF'S NOIRLAB), M. ZAMANI & D. DE MARTIN (NSF'S NOIRLAB)

△ Lunar eclipse from the ISS

INTERNATIONAL SPACE STATION, 16 MAY 2022

Those of us who got up early to watch the lunar eclipse only to be thwarted by clouds will envy the ISS's unobstructed view of the event. A shadow crosses the Moon on the horizon while to the right is the Rassvet docking module, the Soyus MS-21 crew ship and the Nauka lab module with its brand-new robotic arm. Also brand new are the SpaceX Crew-4 that arrived on 27 April: ESA's Samantha Cristoforetti and NASA's Kjell Lindgren, Jessica Watkins and Bob Hines (who took this shot).

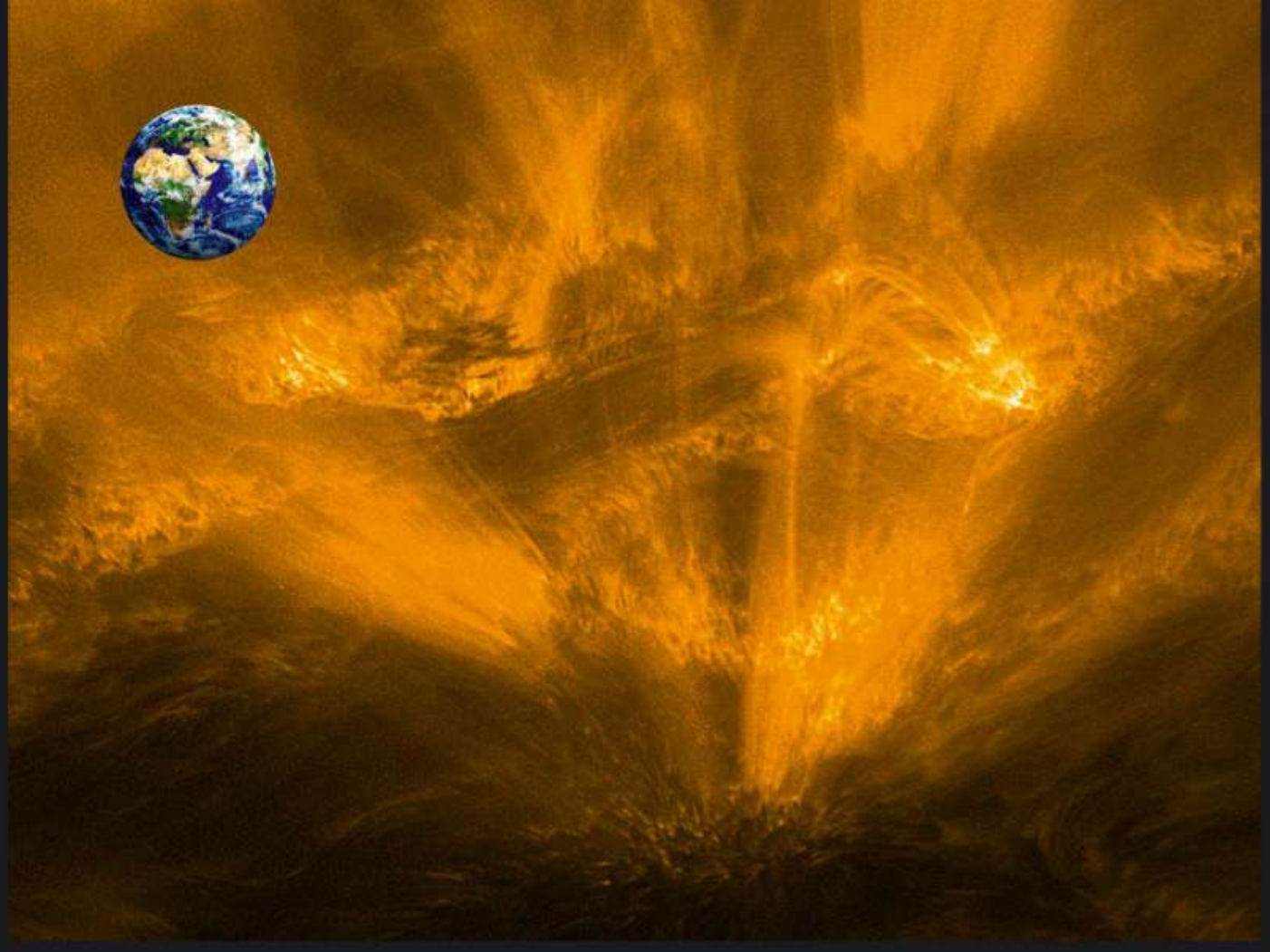
Jewel box of galaxies ▷



HUBBLE SPACE TELESCOPE, 6 MAY 2022

This kaleidoscopic scene rich with thousands of jewel-like galaxies was imaged as part of the Frontier Fields program to study dark matter and the early Universe. An area near Abell 370 in the constellation of Cetus, it provides a corridor back through space and time, from massive yellow elliptical galaxies, to smaller bright blue spirals and the farthest, billions-of-years-old red galaxies. Photobombing the image are the arcing trails of asteroids in our own Solar System.

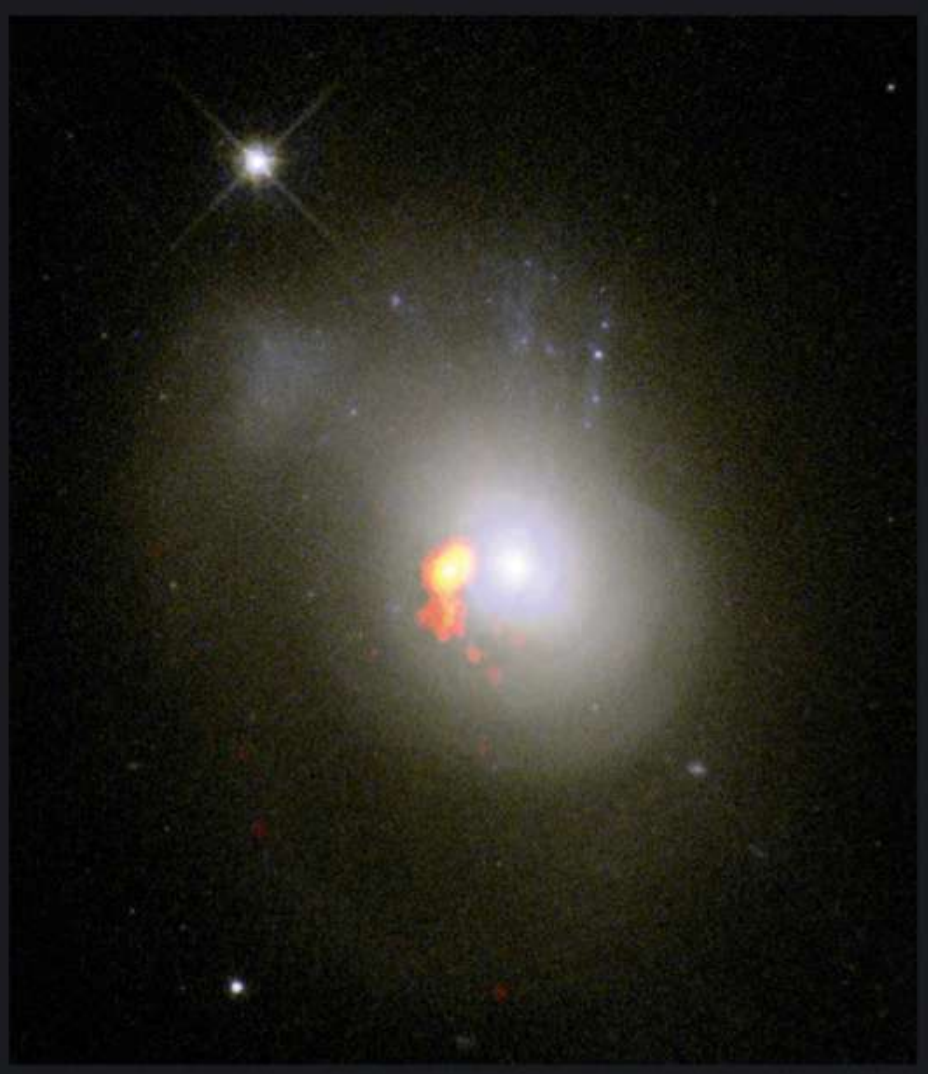
NASA, NASA/ESA AND B. SUNNQUIST AND J. MACK (STSCI), ESA & NASA/SOLAR ORBITER/EUI TEAM, ALMA (ESO/NAOJ/NRAO)/S. DAGNELLO (NRAO/AUI/NSF), EHT COLLABORATION

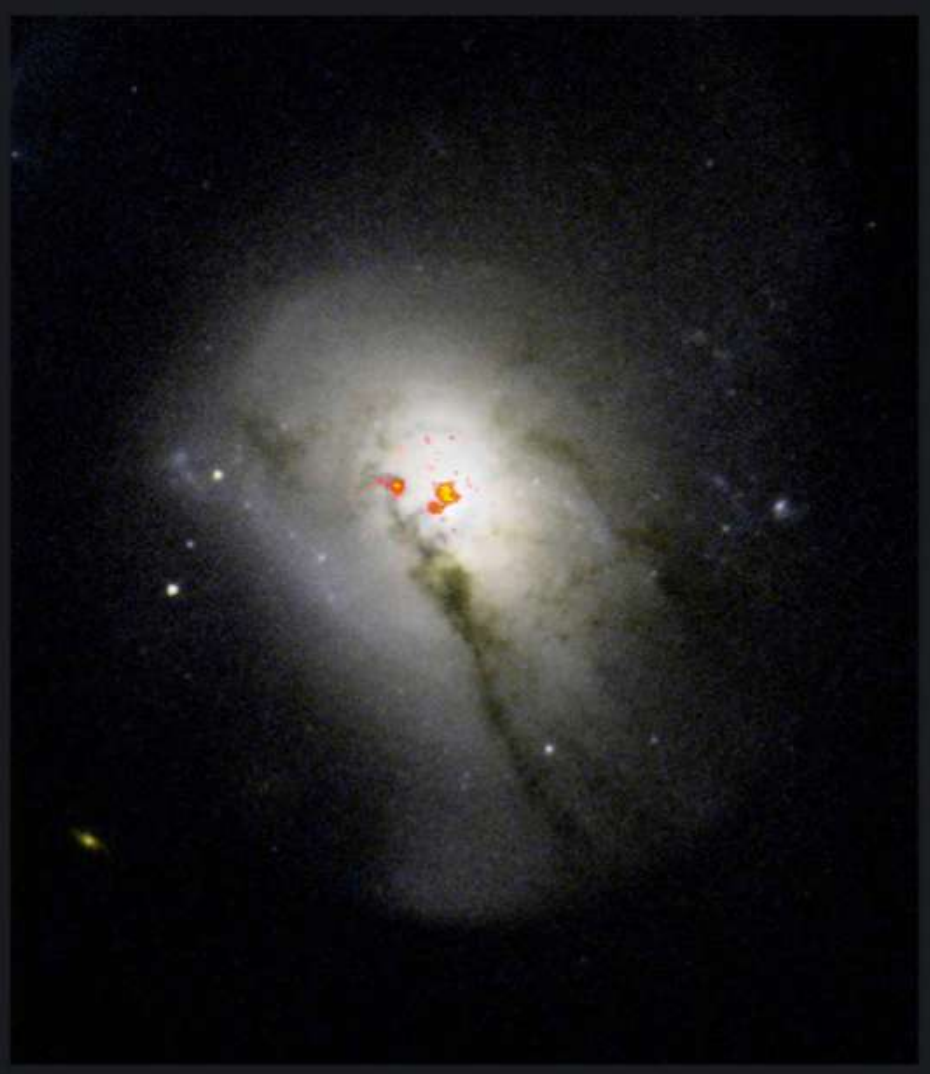


◁ Prickly heat

SOLAR ORBITER, 18 MAY 2022

This intriguing feature on the surface of the Sun was imaged by the ESA/NASA Solar Orbiter on 30 March 2022, four days after the spacecraft's close approach to our host star. Solar scientists don't yet know exactly what the feature is, but it has already been dubbed the 'space hedgehog'. And while this unusual formation may be classed as 'small scale', don't be fooled: it stretches 25,000km across, making it about twice as wide as Earth (shown to scale).





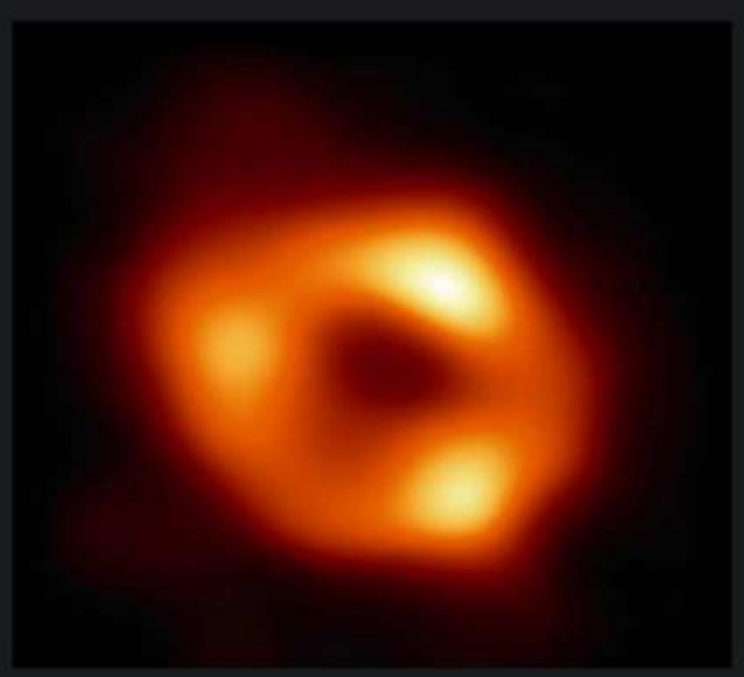
△ Not running on empty after all

ATACAMA LARGE MILLIMETER/SUBMILLIMETER ARRAY, 25 APRIL 2022

Galaxies thought to be fully depleted of gas after violent collisions and mergers with others have been found to contain surprising reserves of star-forming fuel. Post-starburst galaxies (PSBs) like 0379 and 0570 (above left and right respectively) have been observed by ALMA to hold nuggets of turbulent, condensed gas in or near their centres. The discovery makes for a puzzle as to why this doesn't trigger new star creation.

MORE **ONLINE**

Explore a gallery of these and more stunning space images

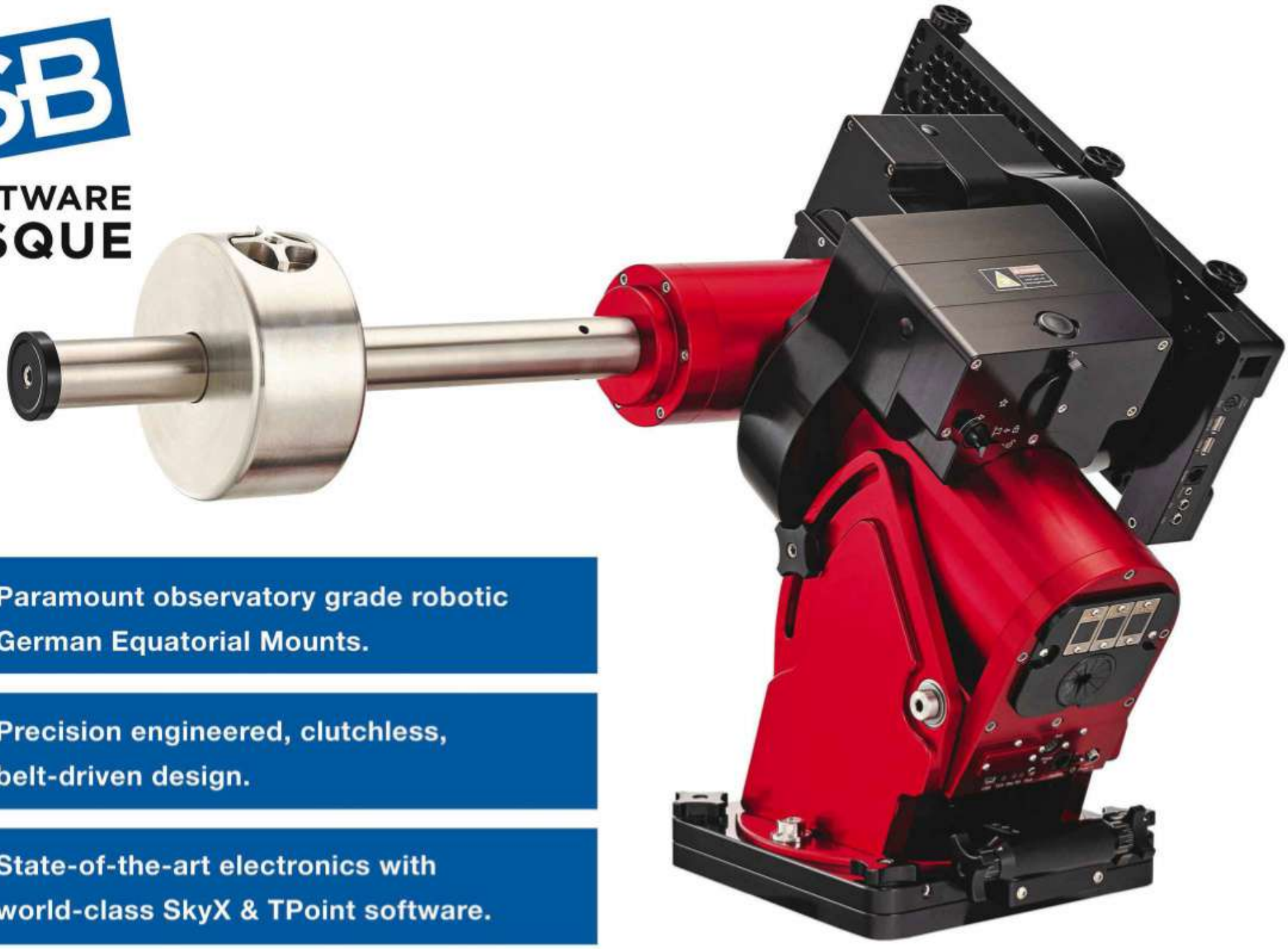


Our local black hole

On 12 May astronomers unveiled the first ever image of our Galaxy's black hole, Sagittarius A*.

Turn to pages 17 and 67 for the full story ▶

SOFTWARE BISQUE



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BULLETIN

Hubble refines the Universe's expansion rate

The new measurement could help solve one of the biggest problems in cosmology

Using over 30 years of observations, the Hubble Space Telescope has helped to create the most precise measure of the expansion of the Universe, known as the Hubble constant. The new value of 73km/sec/Mpc (kilometres per second per megaparsec) is now accurate to within one per cent, and means it would take the Universe 10 billion years to double in size.

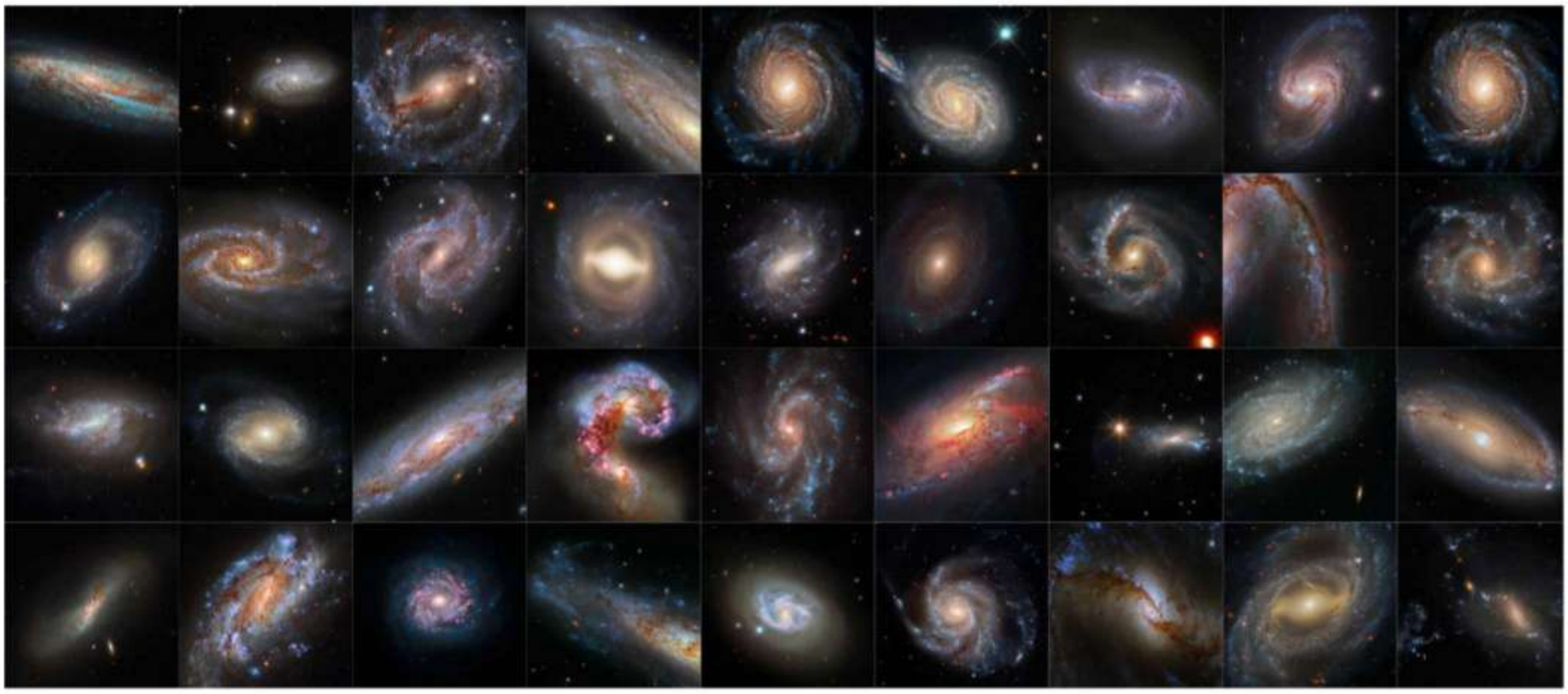
"The Hubble constant is a very special number. It can be used to thread a needle from the past to the present for an end-to-end test of our understanding of the Universe," says Licia Verde, from the University of Barcelona, who took part in the study.

Astronomers have long been plagued by a serious issue when measuring the expansion rate of our Universe – it changes depending on whether you measure it with local objects, like supernovae in nearby galaxies, or the cosmic microwave background (CMB), relic radiation from the very early Universe. Both measurements have been taken many different times by different teams, but have remained stubbornly mismatched.

The distant measurement from the CMB was initially far more precise, so to bridge the gap in our understanding a team of astronomers used Hubble data of supernovae to measure the nearby value to the same accuracy. As suitable supernova only occur roughly once a year, it has taken Hubble's entire lifespan so far to build up a catalogue of 42 examples.

"This is likely Hubble's magnum opus, because it would take another 30 years of Hubble's life to even double this sample size," says Adam Riess from the Space Telescope Science Institute, who lead the study.

https://hubblesite.org



NASA, ESA, ADAM G. RIESS (STSCI, JHU)

▲ **These 36 galaxies imaged by Hubble play host to both Cepheid variables and supernovae used to measure the Universe's expansion**

Comment

by Chris Lintott

This new result does nothing to relieve what's politely called the 'tension' between different methods of determining the expansion speed of the Universe. And in fact, it makes the disagreement worse.

After many years of scrutiny, it seems unlikely that cosmologists on either side of the divide have made a mistake. Instead, we must be missing something. The fun solution is to change our cosmological model, invoking new physics. More likely, our understanding of the CMB, or more likely of how supernovae work, has something missing.

While theorists wrestle with the problem, new ground-based surveys like that planned by the Vera Rubin Observatory, as well as ESA's Euclid mission, are on the way. The scientists behind them will be delighted to have Hubble leave them this puzzle to poke at.

Chris Lintott co-presents *The Sky at Night*

ILLUSTRATION AURORE SIMONNET AND NASA'S GODDARD SPACE FLIGHT CENTER, SPITZER: NASA/JPL-CALTECH; MIRI: NASA/ESA/CSA/STSCI, UNIVERSITY OF CANTERBURY, HEATHER ROPER

It's not the black hole itself that echoes, but the gas that surrounds it, illuminated by energetic X-rays

Listening in to black hole echoes

Bouncing X-rays could help reveal the hidden landscape surrounding black holes

As the team behind the recent image of the Milky Way's heart know only too well, investigating black holes is incredibly difficult because they are exactly that – black. The Event Horizon Telescope team managed it using a planet-sized telescope, but in the meantime, another team has been using a more unusual method – echolocation.

The Milky Way is home to tens of millions of black holes, left behind by supernovae. Most of the time they are invisible until they feast on the gas around them, creating a burst of X-rays. This then bounces and echoes off the surrounding gas, illuminating it. Now a team of astronomers from MIT has tracked down a total of 10 echoing black holes – eight of which were new discoveries – and watched them for several months.

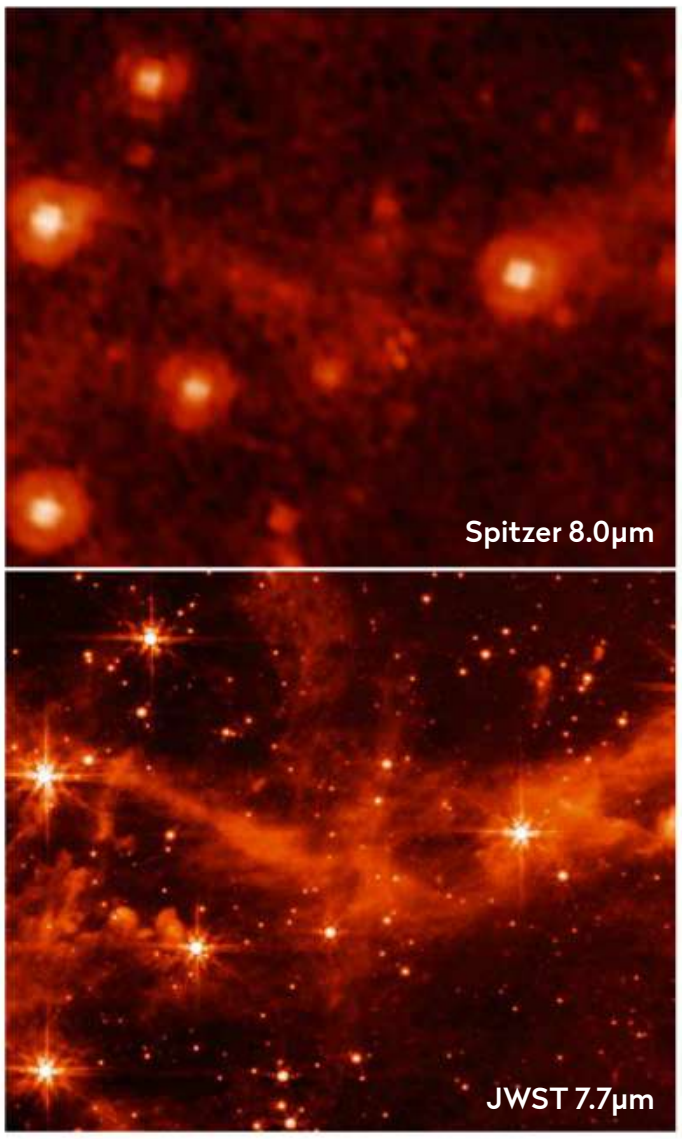
"These black holes range in mass from five to 15 times the mass of the Sun, and they're all in binary systems with normal, low-mass, Sun-like stars," says Jingyi Wang from MIT, who led the study.

By comparing the delay in light from the black hole's corona arriving at Earth to the arrival of echo, the team was able to create a map of gas around the black hole.

This revealed that the black holes initially go through a 'hard' stage, lasting a few weeks, where they form coronas of high-energy photons and shoot out jets of material at near light speeds. The jets and corona first begin to sputter, before transitioning back to a low-energy 'soft' phase. The team saw that as the black hole transitioned from hard to soft, the time lag of the echo increased, suggesting the gap between the corona and the surrounding disc was growing larger. One explanation is that the corona experiences a brief expansion outwards as it finishes its cosmic feast, then retracts.

"We're at the beginnings of being able to use these light echoes to reconstruct the environments closest to the black hole," says Erin Kara from MIT. "Now we've shown these echoes are commonly observed, and we're able to probe connections between a black hole's disc, jet and corona in a new way."

▶ Turn to page 67 for more on the image of the Milky Way's central black hole.



▲ **The image from JWST, above, is noticably sharper than Spitzer's, top, with the stars more tightly defined and the gas cloud more detailed**

James Webb Space Telescope fully focused

The telescope is almost ready to begin scientific operations

The James Webb Space Telescope (JWST) has reached another milestone after aligning all four of its science instruments, meaning the telescope is now fully focused. The JWST team will now move onto the science instrument commissioning phase, when they will set up and calibrate the experiments ready to begin the science phase in the summer.

The telescope's performance has exceeded even the most optimistic predictions and as the first test images come in, its true potential is becoming readily apparent. This image shows an area of the Large Magellanic Cloud taken both by JWST and its predecessor, the Spitzer space telescope, at comparable wavelengths. What are fuzzy blobs and vague hazy patches with Spitzer are now resolved into sharp stars and nebulous wisps of dust, giving a tantalising glimpse of what the JWST will be capable of when it begins its true scientific operations.
www.jwst.nasa.gov

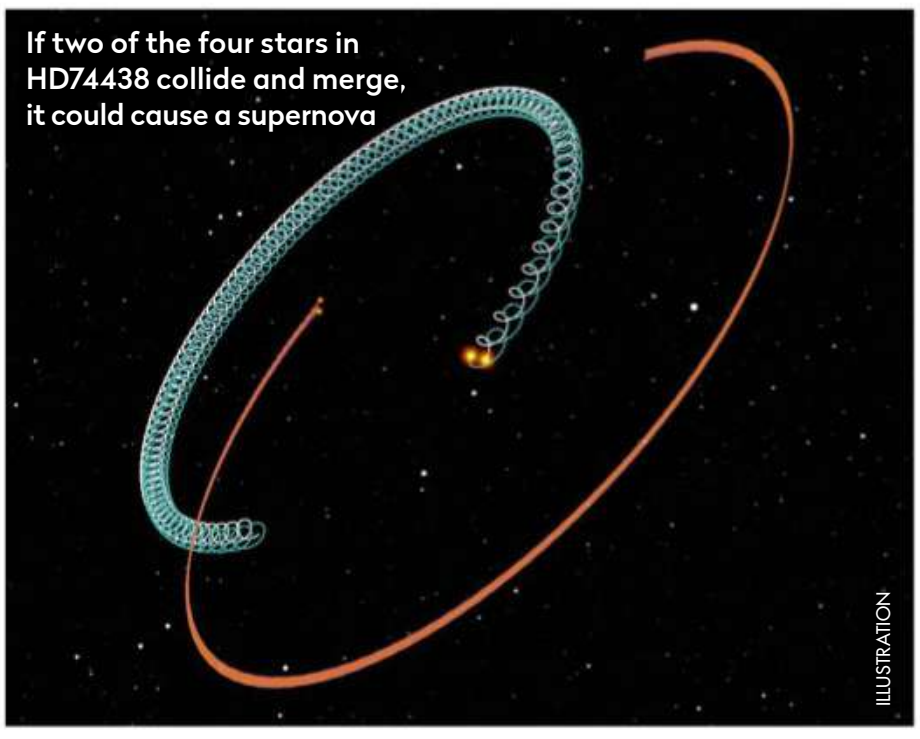
Crashing quads could create supernovae

A rare quadruple star system could be heading towards a supernova, but in a way never seen before. The system, HD74438, is a double binary found by Gaia in 2017. Now, after years of follow up observations, the research team determined that the outer pair is disrupting the inner one's orbit, making it increasingly elliptical.

The more elliptical the orbit becomes, the higher the chance that two of the stars might one day collide and merge. If they did so, they would cross what's known as the Chandrasekhar limit, a mass 1.4 times greater than the Sun's, above which all stars are destined to undergo a supernova.

"Interestingly, 70 to 85 per cent of all thermonuclear supernovae are now suspected to result from explosions of white dwarfs with sub-Chandrasekhar masses," says Karen Pollard from the University of Canterbury in New Zealand. "As a result of mass transfer or mergers, these white dwarfs can explode as a thermonuclear supernova explosion."

The discovery is just one way such transfer can happen, showing there could be many more routes to supernova waiting to be discovered.
www.canterbury.ac.nz



If two of the four stars in HD74438 collide and merge, it could cause a supernova

NEWS IN BRIEF

OSIRIS-Rex to Apophis

NASA has approved a second space rock stop-off for its asteroid investigating OSIRIS-Rex after dropping off its sample of Bennu at Earth on 24 September 2023. Its next target is Apophis – a near-Earth asteroid that will pass just 32,000km away from Earth on 13 April 2029 – and it will spend at least 18 months in orbit, though it will be unable to collect a surface sample.

Mars's solar-powered dust storms

The Sun could be to blame for Mars's annual dust storms, which cover huge swathes of the planet, according to a new report. The study found the planet was taking in more energy from the Sun than it was radiating out as heat, and this energy excess could be fuelling the storms.

Black widow binary

Astronomers have discovered a 'black widow binary' – where a pulsar slowly circles and consumes a smaller companion star – 3,000 lightyears from Earth. With the neutron star lapping its doomed companion once every 62 minutes, this binary has the shortest orbit of the 20 known so far.

NEWS IN BRIEF

NASA/JPL-CALTECH/UCLA/MPS/DLR/IDA, BOEING, NASA/JPL-CALTECH

Ceres formed far out

A novel set of simulations has shown that dwarf planet Ceres could have formed further out, then migrated to its current position in the asteroid belt. The discovery adds weight to the theory that Ceres is a protoplanet that never made it to full planethood, rather than forming like the other, smaller asteroids.

Dead galaxies still gassy

Galaxies which have just finished a period of extreme star formation, known as post-starburst galaxies, could still be rich in highly compact gas, a new study has found. However, the galaxies are not using this gas to create stars as would be expected, leading astronomers to question what is preventing the formation process.

Mars's moving glaciers

The carbon dioxide glaciers found at Mars's south pole have been moving for at least 600,000 years, a new study has found. The glaciers have flowed downhill and ponded in troughs and basins, at rates up to 100 times faster than water ice under Martian conditions, creating sheets up to 1km thick.

BULLETIN

Boeing's Starliner crew vehicle reaches the ISS

The second commercial crew vehicle is cleared for human tests

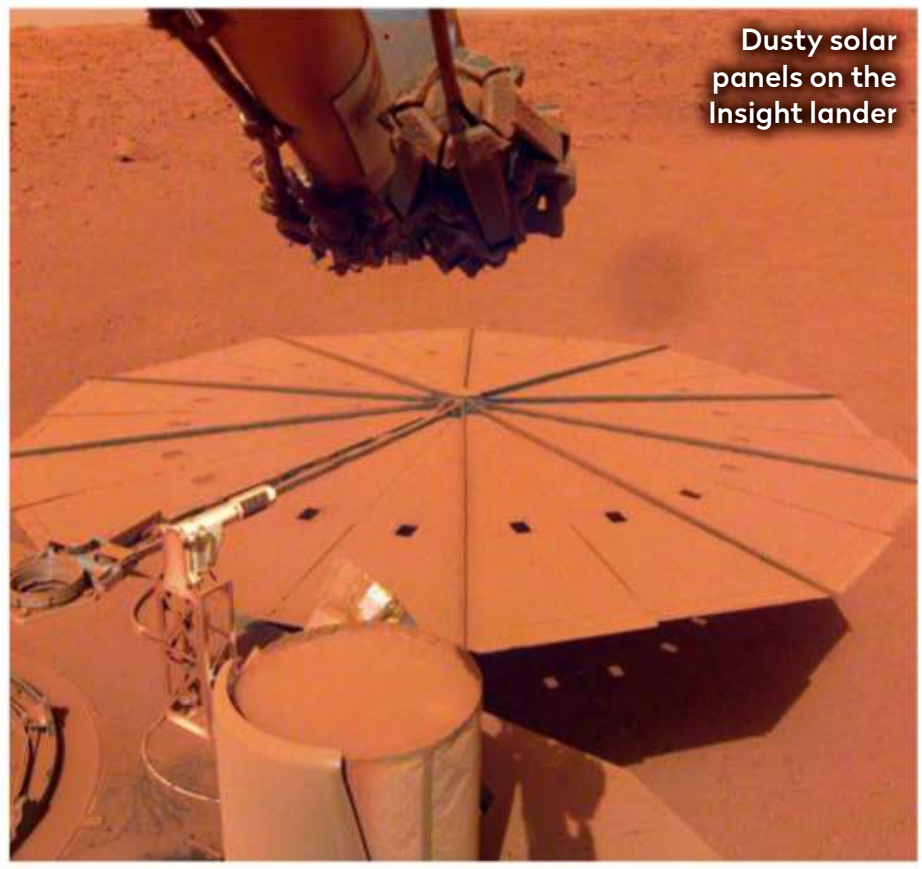
On 19 May, spaceflight company Boeing finally flew the first successful uncrewed test mission of its Starliner crew module, which will serve as a 'taxi' carrying astronauts to and from the International Space Station. It arrived at the ISS the next day, where it was checked out by the station crew before returning to Earth on 26 May. The capsule is reusable, and so will now be refurbished ready for its next flight.

The success marks the end of a string of bad luck for Starliner, beginning in December 2019, when the spacecraft made its first uncrewed flight but was unable to reach the altitude needed to dock with the ISS. After a major review of the spacecraft by NASA, the test was due to be reattempted in August 2021, but issues with the capsule's propulsion system meant it was delayed a second time.

www.boeing.com/space/starliner

▲ **The Starliner crew ship pictured from the ISS as it approaches for docking during its test flight**

Martian dust means InSight's end is in sight



Dusty solar panels on the Insight lander

The InSight lander is losing its battle with Martian dust, and is now expected to reach the end of its science mission this summer, NASA has announced. The lander's solar panels are now so dusty that they produce only 10 per cent of the 5,000 Watt-hours of power they did when the six-metre-wide robot first arrived on the planet.

The issue of dust build-up blocking solar panels has been known since the Viking missions of the 1970s. The Spirit and Opportunity rovers were spared InSight's fate as their solar panels were cleaned at random intervals by gusts of wind. InSight – a stationary platform located near the planet's pole – hasn't been so lucky.

To preserve power, the InSight team has positioned the lander's robot arm in a 'retirement pose' where it can still take images of the surrounding area without having to move.

The spacecraft will continue to use its seismometer to hunt for marsquakes. Since landing on 26 November 2018, it has detected more than 1,300 tremors, helping to build up an image of the inner structure of Mars and its crust, mantle and core.

https://mars.nasa.gov/insight

It's love at first light!

ATIK CAMERAS

The Heart Nebula imaged by Julian Shroff with an Apx60

Introducing the Apx26, Atik Cameras' brand-new 26-megapixel CMOS camera, and latest addition to the Apx series.

Hot on the heels of the Apx60 is the Apx26, utilising the Sony IMX571 CMOS sensor. This 26-megapixel sensor has low read noise, high quantum efficiency, and 16-bit analogue-to-digital conversion. It's the perfect combination of versatility and large-format imaging.

The Apx26 comes complete with high-performance cooling, anti-condensation and anti-reflection optics, as well as easy chip adjustment. The camera has a large memory buffer to prevent image artefacts and dropped frames. Additionally, the Apx26 is compatible with Atik's intuitive software, and offers customary premium build quality.

You can order the Apx26 NOW!
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See the full Atik range
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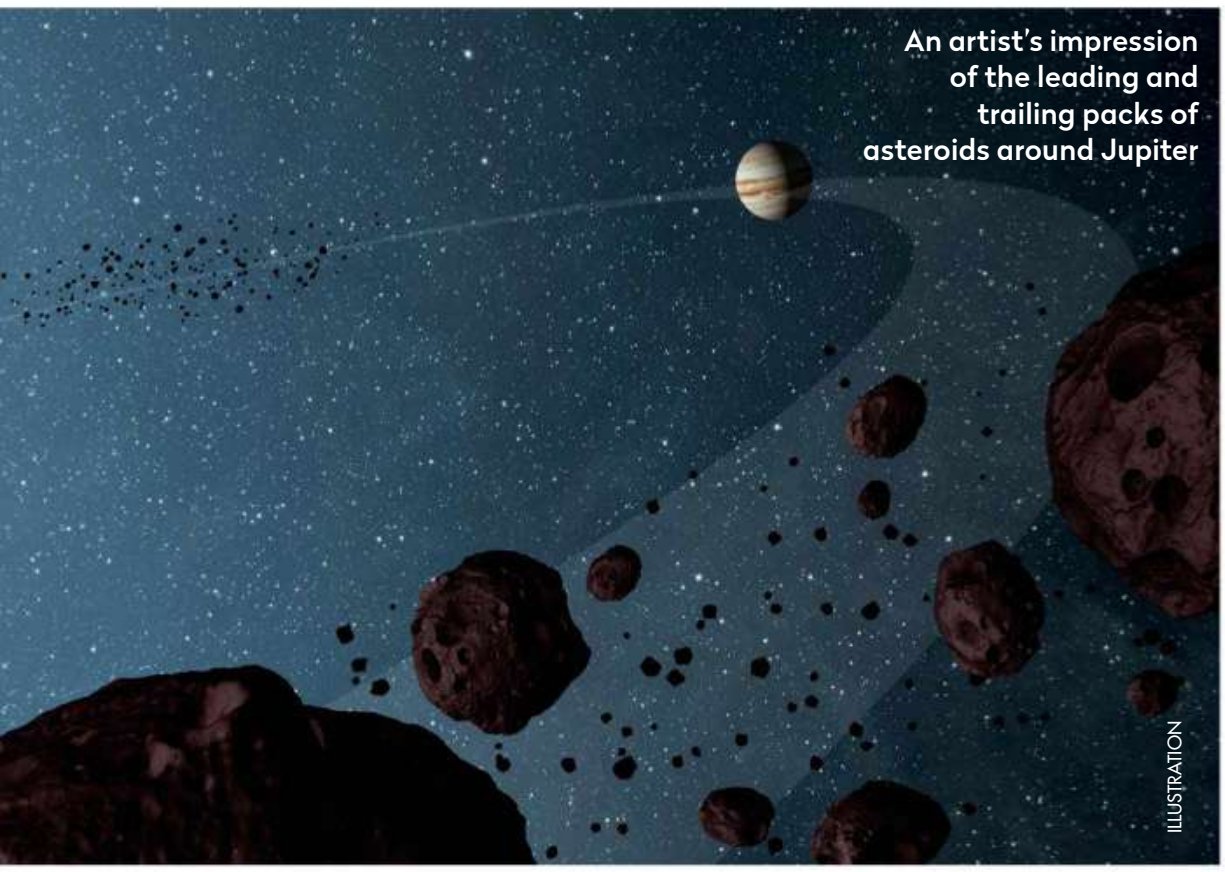
Apx26

WIN!

To celebrate the launch of our 26-megapixel camera, we're offering you the chance to win a brand-new Apx26. Simply scan the QR code or head over to the Apx26 competitions page on our website, and use the code **S@N22** to enter. Competition closes 29 July 2022. T&C's apply.

Our experts examine the hottest new research

CUTTING EDGE



An artist's impression of the leading and trailing packs of asteroids around Jupiter

ILLUSTRATION

NASA/JPL-CALTECH, EHT COLLABORATION

Jupiter's asteroid swarms

The planet has hundreds of thousands of rocky bodies in front and behind

The Lagrangian points around an orbiting body are special points in space, where the gravitation of the Sun pulling in and the centrifugal force of our motion flinging out act to balance each other out. These regions around the Earth are very useful for spacecraft. For example, the SOHO solar observatory has been parked in the L1 Lagrangian point between the Sun and Earth, and the WMAP probe that mapped the remnant heat from the Big Bang is at L2 beyond the Earth. There are also Lagrangian regions situated 60° leading and trailing any massive object in its orbit. In Jupiter's case, its L4 and L5 regions are each populated by a swarm of asteroids. They are known collectively as the Trojans, with the largest of them named Agamemnon, Achilles and Hector.

These Trojan asteroids aren't thought to have formed at 5.2 AU, the distance of Jupiter's current orbit from the Sun, but it's unclear exactly where they came from.

Were they originally icy planetesimals from beyond Neptune, scattered and then captured by Jupiter during a period of orbital instability early in Solar System history? Or perhaps Jupiter collected them when it formed further out, before migrating inward towards the Sun. Clues to the origin of the Trojans can be provided by studying the distribution of their sizes and surface characteristics. Kotomi Uehata, at the Department of Planetology, Kobe University, Japan, and her colleagues have surveyed the Trojan asteroids in the L5 Lagrangian region, trailing behind Jupiter in its orbit. They used the Hyper Suprime-Cam (HSC) fitted to the 8.2 m Subaru Telescope at the Mauna Kea Observatory on Hawaii.

Ln of Troy

They found a total of 189 L5 Trojans down to an apparent magnitude of +24.0, corresponding to objects with a diameter of between 2 km and 10 km. As expected, the size distribution of these objects follows a power law – there are exponentially more smaller bodies than larger ones.

They also showed, by comparing with an earlier study the team had conducted on the L4 Trojan swarm, that this size distribution is the same for both Trojan swarms, indicating that they came from the same primordial population. In total, Uehata calculates that there are about 260,000 Trojan asteroids bigger than 1 km trapped in Jupiter's L4 and L5 Lagrangian regions – roughly 10 times fewer than there are in the main asteroid belt.

"The Trojans aren't thought to have formed in Jupiter's current orbit around the Sun, but it's unclear exactly where they came from"

Interestingly, though, Uehata discovered that in the L4 swarm ahead of Jupiter, there are about 40 per cent more asteroids with a size larger than 2 km, than there are in the L5 Lagrangian region trailing behind the planet. This asymmetry in the L4 and L5 populations supports the theory that the Trojans were captured by Jupiter as it formed further out in the Solar System before migrating inward.

The Trojans are a fascinating category of objects, and studying them close-up promises to teach us a great deal about the origin of small icy bodies from further out in the Solar System. Luckily, there is already a space probe en route to explore asteroids in both of Jupiter's Trojan swarms. The Lucy probe, launched in October 2021, will fly by four L4 Trojans (as well as a main-belt asteroid on its way out) before arriving in the L5 swarm in 2033.

Prof Lewis Dartnell is an astrobiologist at the University of Westminster

Lewis Dartnell was reading... *Size Distribution of Small Jupiter Trojans in the L5 Swarm* by Kotomi Uehata et al **Read it online at: https://arxiv.org/abs/2204.08617**

Our Galaxy has a heavy heart

Taking a look at the science behind the image of the Milky Way's black hole

Prof Chris Lintott is an astrophysicist and co-presenter on *The Sky at Night*

The Event Horizon Telescope's image of the silhouette of the black hole at the centre of the Milky Way appeared on news bulletins and front pages around the world, but the real jam in this celestial doughnut is in the series of papers released at the same time. So what have we learnt about Sagittarius A*, our local supermassive black hole?

For starters, it's slightly more massive than we thought. Instead of just producing an image, the data from the telescope must be modelled, with a computer working out what black holes of varying properties might look like and comparing the result to the observations collected from the EHT's network of telescopes. This process suggests a black hole four million times the mass of the Sun.

One of the reasons we've had to wait until now to see these images, when those of the larger but much more distant black hole in M87 were released in 2019, is that the activity observed in the material surrounding the black hole makes forming an image hard. The largest scale structures seen in the images change from hour to hour, and on smaller scales things change from minute to minute. This activity must be associated with the material surrounding the black hole, rather than the black hole itself, but it is still impressive.

> ***"The largest-scale structures seen in the images change from hour to hour, and on smaller scales, from minute to minute"***

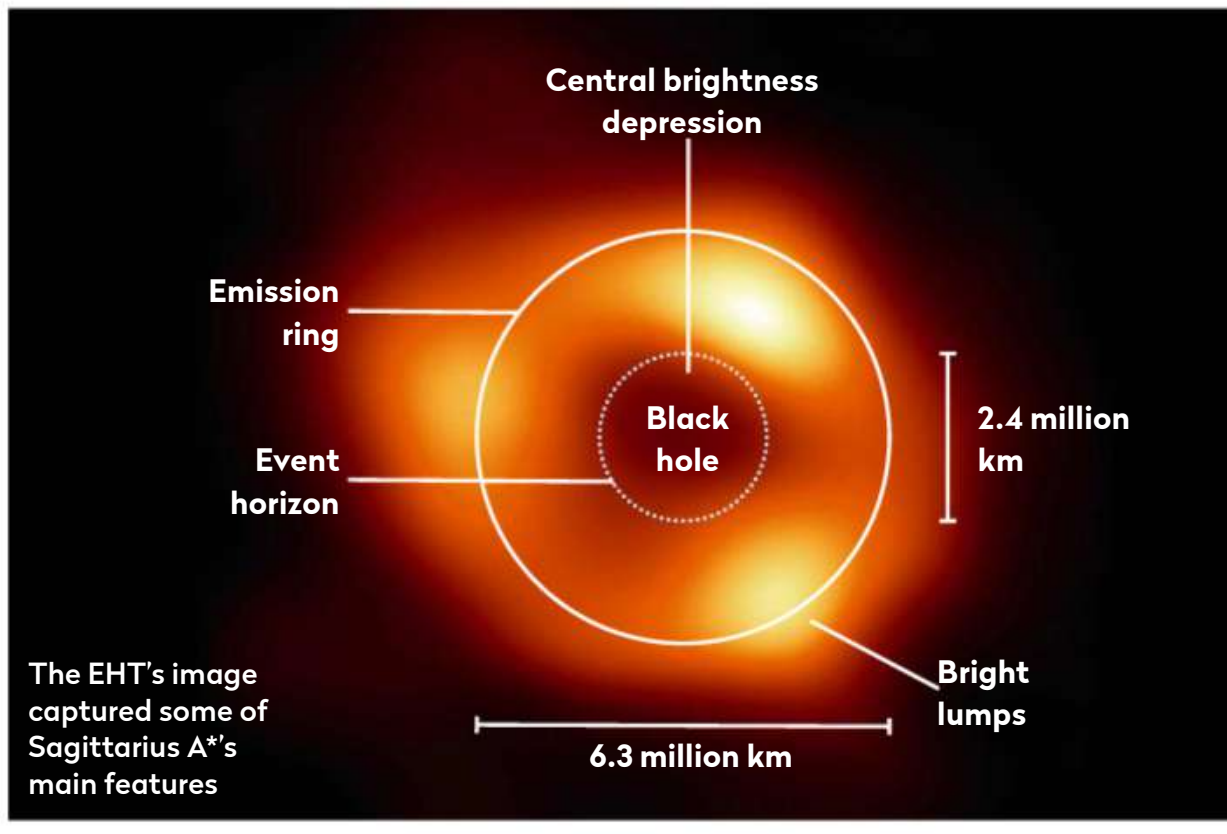
Lumpy material

Once the variability has been accounted for, a careful measurement of the size of the silhouette can be made. This is useful in testing the basic general relativistic equations that describe the black hole. It turns out all is as expected, and the data fits perfectly with what we think it should be for a slowly rotating black hole. The most distinctive feature of the images is the three lumps which surround the central shadow. The position of these is actually rather uncertain; models which place them at different points around the centre are almost equally consistent with the data collected by the telescopes. Nonetheless, there is some lumpiness in the material surrounding the black hole, presumably sculpted by powerful magnetic fields in the region. There's a hint in these images of the detail we'll see in the next phase of EHT observations, which should provide a movie showing changes around the black hole.

In the meantime, many of my colleagues were surprised that the image indicates that the accretion disc around the black hole is somewhat inclined toward us. As we're embedded in the Milky Way's disc, that means that material falling into the black hole doesn't arrange itself to align with the wider Galaxy's structure. It seems likely that the angle changes over time, as mergers and accretion of material swept into the centre change the black hole's spin. Given that jets from material accreting onto the black hole are believed to be capable of driving gas from the Galaxy, switching off star formation, the fact that they could swing around in any direction may prove to be important.

Intriguingly, the authors note that no single model of the material around the black hole can account for all aspects of the data. The doughnut at the centre of our Galaxy may surprise us yet.

▶ **Turn to page 67 for more on Sagittarius A***



The EHT's image captured some of Sagittarius A*'s main features

Chris Lintott was reading... *Focus on First Sgr A* Results from the Event Horizon Telescope, a collection of papers on the image*
Read it online at: https://iopscience.iop.org/journal/2041-8205/page/Focus_on_First_Sgr_A_Results

The Sky at Night TV show, past, present and future

INSIDE THE SKY AT NIGHT

In the June episode of *The Sky at Night*, Astronomer Royal **Martin Rees** takes a look back over the last 50 years of astronomical innovations and progress.

As every reader of *BBC Sky at Night Magazine* knows, astronomy is on a roll – and has been for the last 50 years. Increasingly powerful observational techniques, in space and on the ground, have revealed a succession of surprises. As someone old (and lucky) enough to have had a ringside seat over this whole time-span, I've been glad to contribute some thoughts to the June episode of *The Sky at Night*, which will dig into its archives to find footage of some of the astronomers and instruments who spearheaded a number of these key discoveries.

In 1964 the discovery of cosmic background radiation – the afterglow of creation – settled the debate between the 'steady state theory' and the 'Big Bang' explanations of how our Universe came into being. We can now speak with confidence about what our cosmos was like right back to just a nanosecond after the 'beginning,' and speculate back even further. Einstein's theory of gravity – general relativity – dates back to 1915, but had a resurgence in the 1960s, stimulated by advances in cosmology. Perhaps even more importantly, though, was the discovery of phenomena – such as pulsars and binary stellar-mass black holes – for which Einstein's theory was not just a tiny correction to Newton, but crucial to understanding them.

A whole raft of observations accumulated during the 1970s, which indicated galaxies weren't mainly made of gas and stars but contained a third key ingredient: dark matter, that contributed five times more gravitating material than ordinary atoms.

Because we can't do actual experiments on stars and galaxies, astrophysics has been hugely boosted by the advent of powerful computers. We can now build virtual worlds, and see what happens when galaxies form or stars collide.

Astronomers everywhere

Astronomers have also become a global community and European collaboration has become especially strong in recent decades. ESA has launched missions – Gaia and Planck, for instance – with strong UK participation. Moreover, optical astronomy in the UK was boosted by the decision to join ESO and gain access to facilities like the VLT – by most criteria the world's number-one optical telescope.

It has, more generally, been gratifying to see the expansion of the UK's astronomy and space community, as an increasing number of universities have turned their physics departments into 'physics and astronomy'. And the widening of interest in astronomy has been stimulated by the

ILLUSTRATION

▲ The Big Bang produced all known matter and dark matter (artist's impression)

MARK GARLICK/SCIENCE PHOTO LIBRARY/ALAMY STOCK PHOTO, MAGANN/ISTOCK/GETTY IMAGES, NASA/JOHNS HOPKINS APL/STEVE GRIBBEN

Martin Rees is the Astronomer Royal and served as President of the Royal Society from 2005 - 2010

greater capabilities of amateur-scale telescopes, and by internet-based citizen science projects such as Zooniverse.

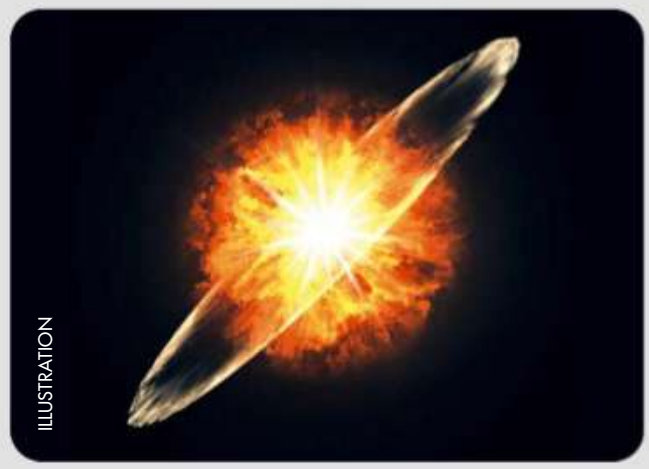
The pace of discovery certainly isn't slackening. Two very different research fields are surging forward fast. One is gravitational waves. LIGO and VIRGO have detected the ripples in space from colliding black holes and neutron stars a billion lightyears away – a technical challenge equivalent to measuring a change at the distance of Alpha Centauri by the thickness of a hair. The other is exoplanets: the realisation that most stars are orbited by retinues of planets. Millions are 'habitable' – perhaps we'll learn in the next 50 years whether they're actually inhabited.

Be that as it may, when the history of science in the last 50 years is written, astronomy and space exploration will surely provide many of the most exciting chapters. Many issues that perplexed astronomers in the 1960s have now been settled; and we're now tackling questions that couldn't even have been posed back then. So the coming decades promise to be as exciting as the last few have been. But progress will, as in the past, be owed primarily to better technology, not to armchair theorists like me.

Looking back: The Sky at Night

10 July 1974

On the 10 July 1974 episode of *The Sky at Night*, Patrick Moore took an image of the red supergiant star Antares. Also known as Alpha Scorpii, Antares is the brightest star in the constellation of Scorpius, and is often referred to as The Heart of the Scorpion.



▲ **Antares will one day go supernova, but we might not be here to see it**

In the northern hemisphere, it is visible as a sparkling red gem in the summer evening sky alongside its much dimmer companion, Antares B. While Antares has a visual magnitude which varies between mag. +0.6 and +1.6, Antares B is a mere +5.5, meaning it is just visible to the naked eye, but its light is swamped by the nearby supergiant.

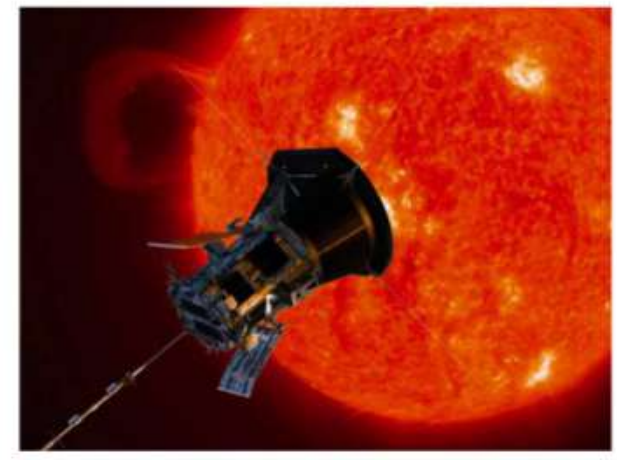
The star's red colour is due to the fact it is in the latter stages of its life span, and has begun to run out of hydrogen fuel in its core. This creates a chain reaction that results in it expanding out many times its original size – it's radius is over three times the distance between the Earth and the Sun. This expansion has caused the outer layers to cool to around 3,500°C, about 2,000°C cooler than the Sun, meaning it appears red in colour, and radiates heavily in the infrared.

As the star progresses into the final stages of its life, it will one day become a supernova. Exactly when this will happen is uncertain, but it will be within the next 10,000 years – relatively soon in astronomical terms.

The Sky at Day

We all know what it's like to plan a night of stargazing, only to find it's forecast to be cloudy...again. So this month the team explore what you can see in the sky during the day. From the Parker Solar Probe to solar observing, Chris and Maggie take a look at what our Sun has to offer, while Pete Lawrence reveals other kinds of celestial phenomena before sunset.

BBC Four, **11 July**, 10pm (first repeat BBC Four, **14 July,** time tbc)
Check www.bbc.co.uk/skyatnight for more up-to-date information



▲ **The Parker Solar Probe is revealing the secrets of our host star (see p60 for more)**

Emails – Letters – Tweets – Facebook – Instagram – Kit questions

INTERACTIVE

Email us at **inbox@skyatnightmagazine.com**

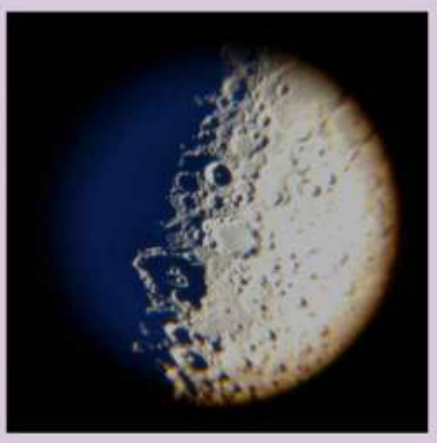
MESSAGE OF THE MONTH

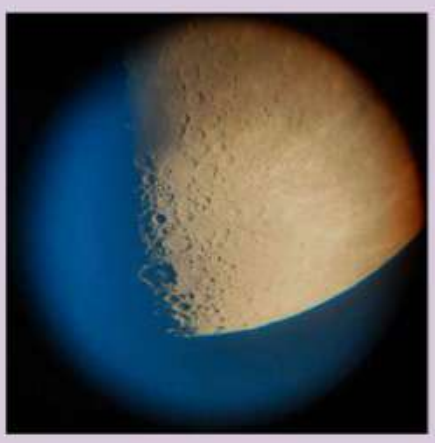
This month's top prize: two Philip's titles

The 'Message of the Month' writer will receive a bundle of two top titles courtesy of astronomy publisher Philip's: Nigel Henbest's *Stargazing 2022* and Robin Scagell's *Guide to the Northern Constellations*

Winner's details will be passed on to Octopus Publishing to fulfil the prize

A 99 leaves Neil wanting Moore





◄ The '99' shape is known as The Eyes of Clavius, and is caused by sunlight hitting smaller crater rims

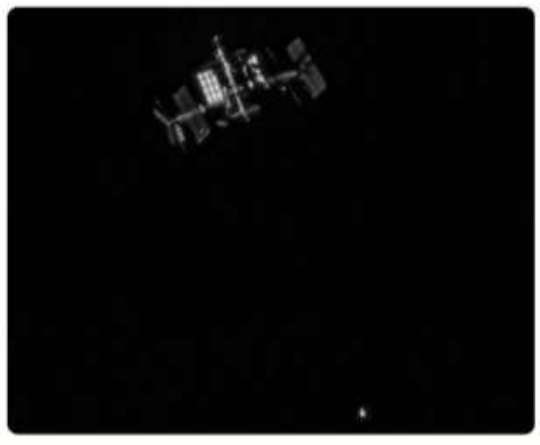
On 10 May I took out my Dobsonian reflector telescope and pointed it at the first quarter Moon. I don't use my telescope as much as I would like to but I was really interested in what I saw that night – what appeared to be the number '99' within a crater on the Moon. I attached my mobile phone adaptor and took these photographs, then I remembered that *Sky at Night Magazine* had recently published a reprint of Sir Patrick Moore's excellent Moon Map (issue 200, January 2022). I looked it out and compared my photos to it, and was able to distinguish that it was crater Clavius in the lunar southern region that I was looking at. This has fired my interest to take my telescope out more and to try taking more pictures of the night sky. I'm especially keen now to try some astrophotography after reading the article in May's magazine on 'Learning About Layers'. Looking forward to it, and thank you for publishing a great magazine.

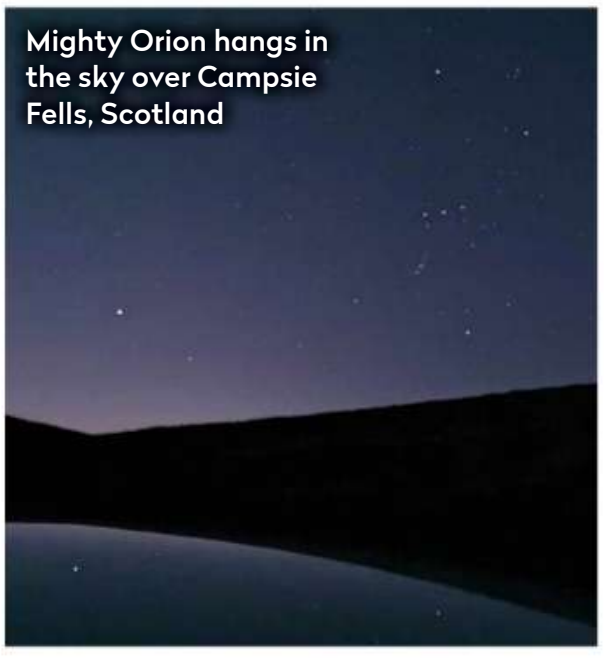
Neil Bailie, via email

What a fascinating account Neil; it's great to hear that you put the poster that came with our 200th issue to such good use! The '99' you imaged in crater Clavius is what's known as a lunar 'clair obscur' effect called the 'Eyes of Clavius'. ***– Ed.***

Tweet

II+II Padawan
@Zs3ml3 • May 21
#Boeing #Starliner on the docking process. Only 208m from the #ISS. 14" Dob with manual tracking, 3xBarlow, @zwoasi 174MM with A.P 642 IR PASS filter. @SkyAtNightMag #SpotTheStation @VirtualAstro





Mighty Orion hangs in the sky over Campsie Fells, Scotland

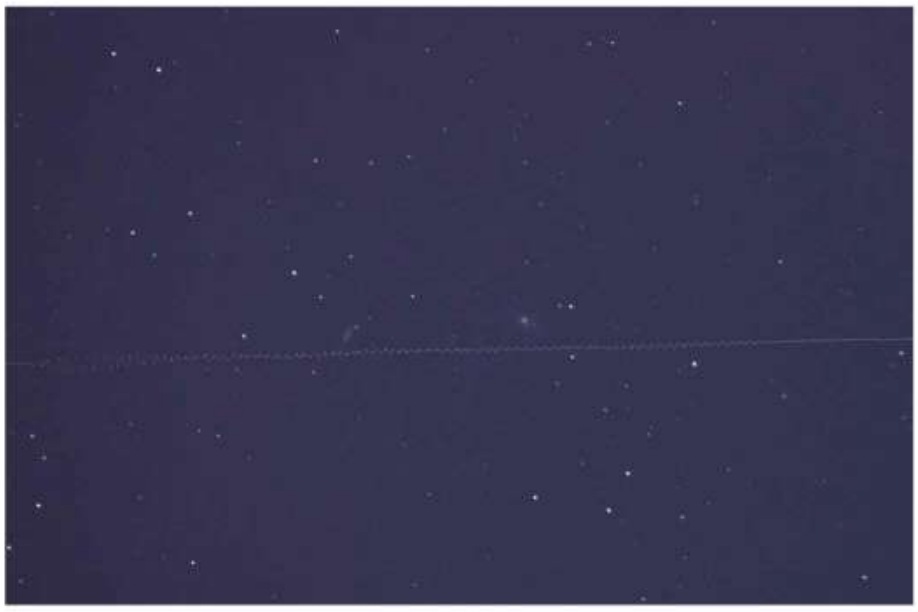
Phone success

I was just reading Pete Lawrence's extremely interesting and helpful online article about taking photos of the night sky, sunsets, etc using your phone's camera (see **https://bit.ly/SANsmartphone**). I also enjoy Pete's section on the show. Astro imaging is an area I've been looking to improve, and I will be trying out his ideas and suggestions. In the meantime, as per the suggestion at the end of the article, I'd like to share this photo I took earlier this year which turned out quite well due to my phone camera's night mode - no manual adjustment necessary. My phone is Huawei P30 Pro. I took these pics at the Campsie Fells, north of Glasgow. The reflection is my car roof, and the glow on the horizon is from the city lights.

Brian McMullan, Bishopbriggs, Glasgow

Clear skies

Thank you to Ron Brecher for his excellent article on observing productivity in March's *Sky at Night Magazine* ('Boost Your Observing and Imaging Productivity',



▲ Have you seen the same wobbly trails as Simon McRoyall?

March 2022 issue). I have to ask though, which planet is he on to have clear nights 60 per cent of the time?!
Alastair McDougall, Wigan

Wobbly trails

I was interested to read the message from Robert Bowers in the May issue ('Interactive', Trail finder, May 2022 issue) about a wobbly trail he captured on 26 February 2022. I observed a similar wobbly trail passing M81 and M82 on the following night and managed to capture this photo of it. I too am extremely curious as to what it might have been.
Simon McRoyall, via email

Varying orbit

I enjoyed Colin Stuart's article ►

ON FACEBOOK

WE ASKED: What's your favourite astronomy song or album?

Carol Miller Major Tom (I'm Coming Home), by Peter Schilling

Paul Beach Fly Me To The Moon, by Frank Sinatra

Keith Moseley Intergalactic Touring Band – a 1970s concept album.

Jimmy McPartland Between the Rings, by Stellardrone

Cheryl Rowlands Urban Spaceman, by Bonzo Dog Doo-Dah Band

Bryony-Mae Hopkinss Life Beyond soundtrack, by MelodySheep

Tim Murphy Into the Void, by Black Sabbath

Dewi Griffiths The Race for Space, by Public Service Broadcasting

Philip Craig Exogenesis Symphony, by Muse

Emma Hugo Starman, by David Bowie

Jim Palmer Alone In The Universe, by Jeff Lynne's ELO

Kris Derry Destination Moon, by Nat King Cole.

Bob Inkster The Space Race Is Over, by Billy Bragg; Monochrome, by The Sundays

Jeff Lewis The Intergalactic Laxative, by Donovan?!

Alan Davidson Space Oddity, by David Bowie

Derek Lightfoot '39, by Queen

Steven Douglas Cygnus X-1 and Countdown, by Rush

David Knight Master of the Universe, by Hawkwind

Steve Green The Sky at Night theme tune!

SCOPE DOCTOR

Our equipment specialist cures your optical ailments and technical maladies

With **Steve Richards**

Email your queries to
scopedoctor@skyatnightmagazine.com

I want to circulate air through my Celestron C11 Edge, which has two vents, to help it reach equilibrium. Is there a DIY option?

JASPAL CHADHA

▲ A Starizona Cool Edge can help a scope hit temperature equilibrium

The Celestron C11 Edge is a Schmidt Cassegrain Telescope (SCT) which has a closed optical tube, so it can take a very long time to reach temperature equilibrium with the outside air. Failure to reach equilibrium results in air currents in the tube, which produce a poor quality view. Anything that you can do to accelerate the cooling down process is welcome and pumping air into the tube can be very effective.

It is quite easy to build a device to do this using an 80mm 12V DC fan, a fine fan filter, a plastic funnel, a length of 22mm overflow water pipe, a 22mm end cap and some duct tape. You should arrange for the telescope to point downwards and for the fan to blow air into the telescope via the visual back port, making sure that the pipe isn't long enough to touch the secondary mirror.

Commercial solutions are also available, such as the Starizona Cool Edge or the Asterion Cooler Cat for SCT and Maksutov Telescopes.

Steve's top tip

Can I use my glasses when observing?

If you suffer from astigmatism, wearing glasses while observing can generally be beneficial. Using high magnifications, however, which results in a small diameter exit pupil (aperture divided by magnification), might allow you to observe well without your glasses. There is no advantage to wearing glasses if you are simply long- or short-sighted, as adjusting the telescope's focus will correct for this.

Because wearing glasses increases the distance you can place your eye to the eyepiece you may not be able to observe the full field of view with some oculars, so it would make sense to buy long eye-relief eyepieces to alleviate this problem.

Steve Richards is a keen astro imager and an astronomy equipment expert

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EDITORIAL
Editor Chris Bramley
Art Editor Steve Marsh
Production Editor Ian Evenden
News Editor Ezzy Pearson
Staff Writer Iain Todd
Reviews Editor Paul Money

CONTRIBUTORS
Paul Abel, Stuart Atkinson, Mark Bowyer, Melissa Brobby, Jamie Carter, Lewis Dartnell, Glenn Dawes, Pippa Goldschmidt, Jane Green, Alastair Gunn, Tim Jardine, Warren Keller, Pete Lawrence, Chris Lintott, Rod Mollise, Chris North, Jheni Osman, Mark Parrish, Nick Pope, Jonathan Powell, Martin Rees, Steve Richards, Katie Sawyers, Stephen Tonkin, Jane Williamson

ADVERTISING SALES
Advertising Manager Andy Williams
+44 (0)117 300 8803, Andy.Williams@ourmedia.co.uk
Inserts Laurence Robertson +353 (0)87 690 2208

PRODUCTION
Production Director Sarah Powell
Production Coordinator Lauren Morris
Ad Services Manager Paul Thornton
Ad Coordinator Charles Thurlow
Ad Designer Parvin Sepehr
Reprographics Tony Hunt, Chris Sutch

LICENSING
Director of Licensing and Syndication Tim Hudson
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Head of Marketing Jacky Perales-Morris
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Instagram

explorer200p • 23 May 2022

The waxing gibbous Moon from the 13th of May 2022. Some nice and steady seeing on the 13th for a nice lunar session. Copernicus crater stands out so well in this phase as well as the Aristarchus Crater, both on the western lunar landscape. Also an inverted view of this phase. It really makes the smaller details pop out. #moon #moonphotography #moonphases #moonpics #photography #spacephotography

▸ in the previous issue ('Seeing the Solar System's Future', June 2022 issue). However, in discussing Earth's distant future there is no discussion of, firstly, our planet's orbit moving outwards as the Sun's mass diminishes, so possibly escaping being engulfed; and, secondly, the unlikelihood of Earth and the other planets being in the same orbits as they are now, in five billion years time. Passing or impacting asteroids and comets, and other events, may change their orbits in the future, possibly very significantly, as happened in the distant past.
Derek Marsh, via email

Most of the predictions about the Solar System in five billion years account for the change in orbit due to the Sun's mass loss. However exactly how the planets' orbits will change is highly uncertain, making Earth's future even more difficult to predict. ***– Ed.***

CORRECTIONS

In the June 2022 issue's 'Inside the Sky at Night', and the Looking Back section covering Voyager 2's encounter with Neptune, we mistakenly said the planet was barely visible to the naked eye and discovered in 1781 by William Herschel. These are the characteristics and discovery history of Uranus. Neptune is invisible to the naked eye and was discovered in 1846 by astronomers who had calculated its position by observing the effects of its gravitational pull.

SOCIETY IN FOCUS

On Sunday 24 April, as part of International Dark Sky Week 2022, the Somerset Levels Stargazers (SLS) celebrated its 10th anniversary by joining forces with the Commission for Dark Skies to present a day-long seminar entitled Dark Skies, Saving the Stars.

The event was held in Othery Village hall on the Somerset Levels, and attendees were also able to join us via Zoom. It was a free community event to raise awareness of the issue of light pollution. Speakers included Bob Mizon, the UK co-ordinator of the Commission for Dark Skies, who emphasised that all living creatures - not just humans - are affected by strong artificial light at night. Becky Collier of CPRE, the Countryside Charity, spoke about its yearly Star Count, and other speakers included Jo Richardson, resident astronomer and dark skies adviser for Exmoor National Park – the UK's first Dark Sky Reserve – Jim Patterson of Moffat Community Observatory in Scotland and Steve Tonkin, who gave a tour of easy-to-see deep-sky wonders.

▲ Bob Mizon of the Commission for Dark Skies explains how dark skies benefit us all

The Somerset Levels Stargazers was founded in 2012 by friends Paul Adamson and John Martin, and holds monthly meetings at Othery Village Hall both in person and on Zoom. It has held many public events and astronomy outreach days for local schools and children's clubs.
Paul Adamson, Chairman, SLS
▸ www.somersetlevelsstargazers.co.uk

We pick the best live and virtual astronomy events and resources this month

WHAT'S ON

Live Home Planet

National Space Centre, Leicester

Hands-on displays, a giant globe, interactive floors and a spectacular marble run are all part of the newly opened Home Planet gallery at the National Space Centre, designed to inspire visitors to consider the human impact on Earth and our place in the Universe. Booking essential. Adults £16.95, children £13.95. **www.spacecentre.co.uk**

Live Herschel to Hawkwind

Observatory Science Centre, Herstmonceux, 2 July, 7:30pm

Rock guitarist and astronomer Peter Williamson gives an entertaining talk that explores the connection between music and the heavens, including live music and a singalong. Tickets £18; £24.50 with food. **bit.ly/3MZhJUi**

Live Saturday Stars

Mills Observatory, Dundee, 2 July, 1pm and 2:30pm

Come along for family-friendly astronomy-themed craft activities followed by some safe solar viewing through the observatory's telescopes, all in a magnificent setting on Balgay Hill. Free. To book a place call **01382 307200**.

Live Craig telescope talk

Bredhurst Village Hall, Gillingham, 29 July, 8pm

Greg Smye-Rumsby brings to life the story of the Craig telescope, for a brief time in the mid-19th century the largest refracting telescope in the world. Was this strange instrument just an expensive folly? **www.midkentastro.org.uk/events**

PICK OF THE MONTH

▲ The Bluedot festival is back: enjoy talks from leading astronomers, live music and much more

LIVE & ONLINE Bluedot 2022

Jodrell Bank Observatory, Cheshire, 21–24 July

Bluedot returns for four days of music, art and space science, all in the shadow of the iconic Lovell Telescope. Among the treats are talks by physicist Jim Al-Khalili, astronaut Tim Peake, space scientist Monica Grady and *BBC Sky at Night*'s Chris Lintott, alongside a bill of stand-up comedy, art and music by the likes of Björk and Groove Armada. There's tons of fun for kids, with science shows, a cinema, hands-on activities and family favourite Brainiac Live. Then, as night falls, visit the pop-up stargazing station for an expert night-sky tour. Day tickets from £35; weekend tickets from £179, including camping. **www.discoverthebluedot.com**

Live Late Night Explorer

Kielder Observatory, Northumberland, weekends, 11:30pm

Wonder at the Moon, planets, constellations and galaxies under the guidance of expert astronomers, and use the observatory's high-quality telescopes. Also enjoy a cosy, log-burning stove and a hot chocolate. Tickets £46. **kielderobservatory.org**

Live Observatory open evenings

St Martin's, Scilly, Tuesdays, 8pm and 9pm

Dark-sky seekers will find some of the UK's best views of the stars at the Community Observatory St Martin's on Scilly. Entry £5. Book at **bit.ly/3KUbMX9**

Live Space science introduction

Royal Institution, London, 29 July, 11am

This holiday workshop for 13 to 15 year-olds explores the Solar System, how maths can calculate the size of the Universe and much more. Tickets £50. **www.rigb.org/whats-on**

NATIONAL SPACE CENTRE, JOD YHARTLEY, LUCAS SINCLAIR X 2

This was Sylvia's promise to you...

A generation ago, a woman named Sylvia made a promise. As a doctor's secretary, she'd watched stroke destroy the lives of so many people. She was determined to make sure we could all live in a world where we're far less likely to lose our lives to stroke.

She kept her promise, and a gift to the Stroke Association was included in her Will. Sylvia's gift helped fund the work that made sure many more of us survive stroke now than did in her lifetime.

Sylvia changed the story for us all. Now it's our turn to change the story for those who'll come after us.

Stroke still shatters lives and tears families apart. And for so many survivors the road to recovery is still long and desperately lonely. If you or someone you love has been affected by stroke – you'll know just what that means.

But it doesn't have to be like this. You can change the story, just like Sylvia did, with a gift in your Will. All it takes is a promise.

You can promise future generations a world where researchers discover new treatments and surgeries and every single stroke survivor has the best care, rehabilitation and support network possible, to help them rebuild their lives.

Big or small, every legacy gift left to the Stroke Association will make a difference to stroke survivors and their families.

Find out how by calling 020 7566 1505

or email legacy@stroke.org.uk

or visit stroke.org.uk/legacy

Rebuilding lives after stroke

The Stroke Association is registered as a charity in England and Wales (No 211015) and in Scotland (SC037789).
Also registered in the Isle of Man (No. 945) and Jersey (NPO 369), and operating as a charity in Northern Ireland.

Stroke Association

FIELD OF VIEW

Astronomer to the stars

Astronomy writer **Jonathan Powell** discovers a royal influence on stargazing

ALEX GREEN/FOLIO

Jonathan Powell is a freelance writer and broadcaster. A former correspondent at BBC Radio Wales, he is currently astronomy columnist at the *South Wales Argus*

The lofty position of astronomer in a royal court has afforded whoever held the position rare privileges, quite apart from the prestige and chance to mingle in higher circles. And for some astronomers, it was also the gateway to pursuing certain personal scientific projects that without royal funding, may never have been realised.

In the very earliest ruling courts, the science of astronomy was still merged with astrology, before the two took their separate paths. Predictions made by these astrologers could weigh somewhat heavily upon them. After failing to predict an eclipse in 2300 BC, two Chinese astrologers attached to the emperor's court soon found they were detached from their heads.

But with the passing of time, attitudes towards the sky changed, as did how it was interpreted. Great astronomers in their own right such as Tycho Brahe, Galileo Galilei and William Herschel were all to be summoned by nobility. During the latter part of the 1500s, King Frederick II of Denmark granted revered Danish astronomer Brahe an estate on the small Swedish island of Hven, and a pot full of cash to build the Uraniborg, an observatory and research establishment where Brahe set about building all manner of astronomical instruments.

But Brahe had a rather despotic relationship with the locals, and fell out of favour with Frederick's successor to the Danish crown. Disagreements ensued, and the party was soon over. However, he bounced straight back by obtaining the position of Imperial Court Astronomer to Holy Roman Emperor Rudolf II in Prague. Interestingly, another astronomical titan, Johannes Kepler, replaced Brahe in that position on his unexpected death in 1601.

A decade later in 1610, Galileo Galilei rather shrewdly dedicated his book Sidereus Nuncius (The Sidereal Messenger) to Cosimo II de' Medici, the Grand Duke of his native Tuscany. This smart move saw Galileo appointed as the duke's mathematician and philosopher, and as a courtier Galileo was duly able to live the life of a gentleman. In later years, however, with his outspoken views on the Copernican theory, Galileo was pronounced to be suspect of heresy, and found himself condemned to a life of imprisonment. In truth, Galileo didn't go to clink, in fact quite the contrary: his cell was first an apartment, then a palace, then a villa.

John Flamsteed may have hoped for similar patronage when, in 1675, he compiled a report on the need for a new observatory, which resulted in the founding of Royal Greenwich Observatory. Indeed, as its director he became the first Astronomer Royal of England. However, the cash was not forthcoming and Flamsteed had to supply all the instruments at Greenwich himself.

William Herschel was more fruitful in securing financial backing. As a result of his discovery of Uranus in 1781, King George III bestowed upon him the title of King's Astronomer, and then later a substantial cash advance. This enabled Herschel to construct the giant 40-foot telescope – the world's largest for 50 years – in Slough.

While the role of royal astronomer may not have proved productive and lucrative for all, the premise of the position, that of furthering science, has brought significant contributions to astronomy.

BBC

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The perfect addition to your stargazing, *BBC Sky at Night Magazine* is your practical guide to astronomy, helping you to discover the night skies, understand the Universe around us and learn exciting techniques for using your telescope.

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BBC Sky at Night MAGAZINE

City life can be hard on stargazers, but there's still hope

From city lights to deep space

PART 2 OF 4

In this second part of a series that looks at urban stargazing through four seasons, **Rod Mollise** reveals the wonders you can discover in the summer night sky...

When it comes to deep sky objects, in the summer the galaxies lying outside the plane of the Milky Way are setting and the marvels within our own Milky Way are on the rise. Urban observers don't have as easy a time viewing the deep sky in summer, as the air tends to be humid and moisture scatters light pollution, making the sky brighter. Nevertheless, it is possible to see a multitude of distant and beautiful objects; you'll just need to tailor what you are looking for according to the weather conditions. On humid summer nights look for bright star clusters, saving more difficult objects like galaxies for times when the weather is dry and the sky is dark.

Whatever the conditions, when deep sky observing there's one characteristic that's most important in the telescope you use – aperture, the size of its light-collecting lens or mirror. A telescope with an aperture of at least 200mm is recommended in areas with light pollution. However, one with a 250mm aperture will be as portable and only a bit more expensive – the extra 50mm shows many more objects and gives more detail, even in bright urban skies.

There are a few different telescope designs to choose from:

Newtonian reflectors, which use a large mirror to collect light, are the least expensive when it comes to cost-to-aperture ratio. But, as the tube in a Newtonian is open to the elements, expect to clean its delicate mirrors regularly. Medium to long focal length Newtonian reflectors are not very portable in apertures above 250mm, and Newtonian mirrors need to be aligned to each other (collimated) frequently.

'Uncle' Rod Mollise is an American amateur astronomer and writer who lives near Mobile, Alabama. He is the author of *Choosing and Using a New CAT*

Refractors use a lens to collect light. Moving from the warmth of indoors to the cold outside deforms a reflector's mirrors, so they take time to acclimatise. But the lens of a refractor is much less affected by changes in temperature. Refractors also rarely require collimation and their images can be very sharp. But you'll often pay more for a 100mm refractor than a 250mm reflector.

Catadioptrics, like the Schmidt Cassegrain Telescopes (SCT), employ a combination of lenses and mirrors. Most SCTs come equipped with computerised drives that will reliably locate objects (which can be difficult to do 'manually' in light-polluted skies), as well as other high-tech features. But, while not as expensive as refractors per millimetre of aperture, they are more expensive than a Dobsonian reflector. The optics of SCTs also require collimation – though not as often as those of Newtonians. ▸

▲ A Newtonian reflector uses mirrors to collect and reflect light to an eyepiece for viewing

▲ A refractor uses glass lenses to bend light and enlarge the image. They're sharp, but expensive

▲ Catadioptric telescopes are a combination of the other two types, and are lighter and more compact

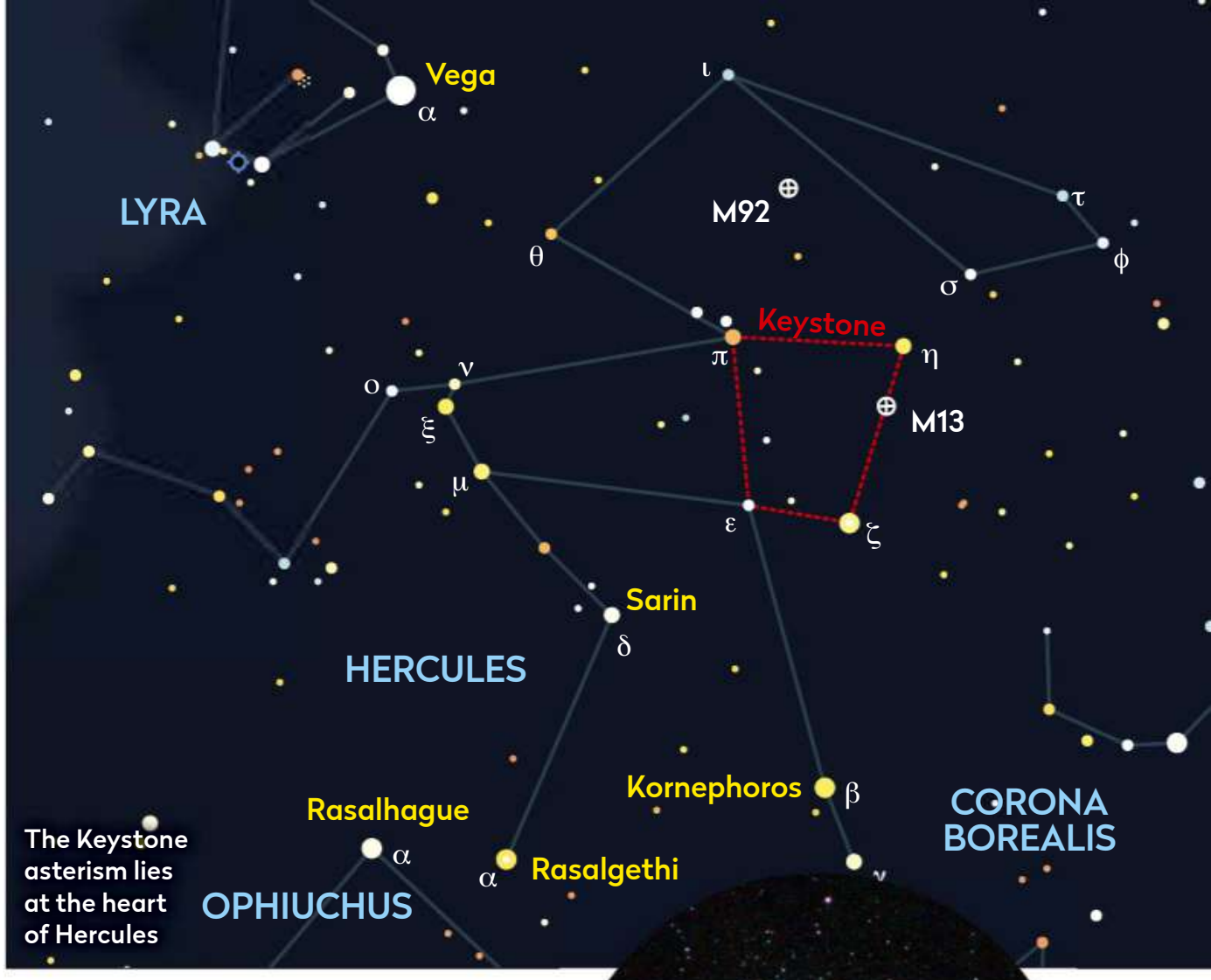
M-GUCCI/ISTOCK/GETTY IMAGES, WWW.ALTAIRASTRO.COM

Summer sights

The season's stunning constellations to explore...

Hercules, the Hero

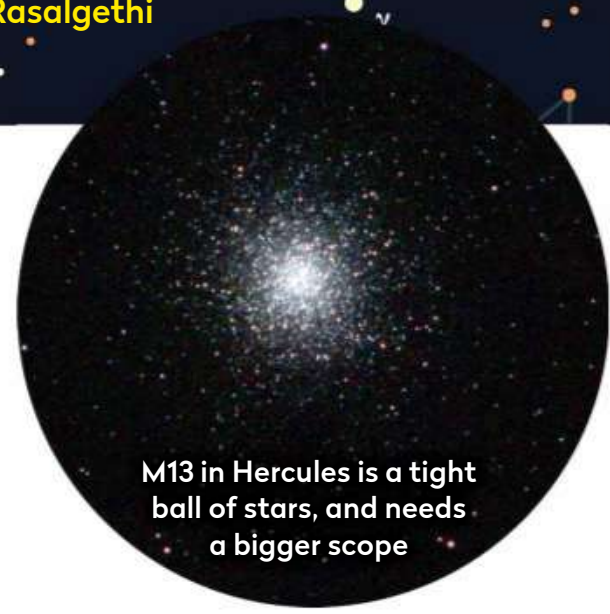
A well-known home of stunning globular clusters



The Keystone asterism lies at the heart of Hercules

Hercules may be on the dim side, but its premier deep sky object, **M13** (mag. +5.8, 20' across) is not. Even a beginner with a non-computerised telescope mount won't have much trouble finding it, roughly midway between the line connecting the two westernmost stars of the Keystone – the lopsided square at the star-pattern's heart. But, while M13 is bright, it is also compact. A 200-250mm telescope turns this 'smudge' into a beautiful ball of stars in the brightest skies.

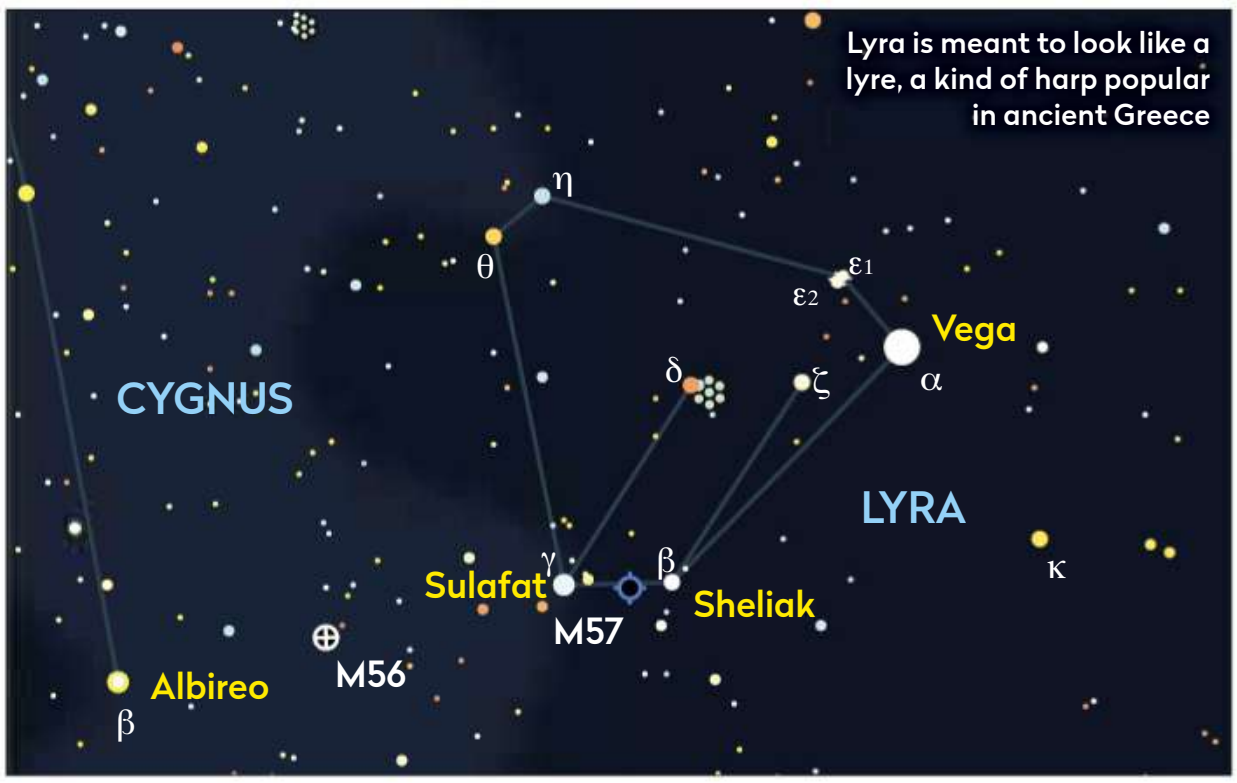
Another notable globular star cluster is **M92** (mag. +6.4, 14' across), which lies away from the Keystone in the northern part of the constellation. While it is actually more tightly concentrated than M13, M92 seems easier to resolve – perhaps because the core isn't as overwhelmingly bright as that of M13. In a 130mm telescope from a suburban location, M92 can appear resolved almost to its centre on a dry summer's evening when the air is steady.



M13 in Hercules is a tight ball of stars, and needs a bigger scope

Lyra, the Lyre

This constellation contains well-known wonders



Lyra is meant to look like a lyre, a kind of harp popular in ancient Greece

Even in the worst urban light pollution, **M57** (mag. +8.8, 3'48"x2'24"), the famous Ring Nebula, is a good target for a 80-100mm telescope, but its shape only becomes evident with an aperture of 150mm or more. A 250mm telescope shows brightness variations in its nebulosity and reveals a faint star embedded in the southwestern end of the ring's disk. The holy grail is M57's central star, the white dwarf left over from the dead sun that created the nebula.

Discovered in January 1779, M57 is a luminous envelope of ionised gas

Globular cluster **M56** (mag. +8.8, 8'48"), in the eastern part of Lyra near the border with Cygnus, is often overlooked. Its small, dim stars are spread far apart, making it more like a rich but dim open cluster.

Lyra's final urban wonder is not a deep sky object, but a multiple star, the famous Double-Double, **Epsilon (ε) Lyrae**, located 1°36' northeast of Vega. At low power an attractive double star is visible, two suns separated by a wide 208". Increase magnification to 200-250x, however, and both of the stars are revealed as doubles themselves. The northernmost pair, ε^1, is separated by 2.78", while the stars of ε^2 to the south are 2.4" apart.

▲ Cygnus is dominated by the Northern Cross asterism, which in northern latitudes is directly overhead at midnight in summer

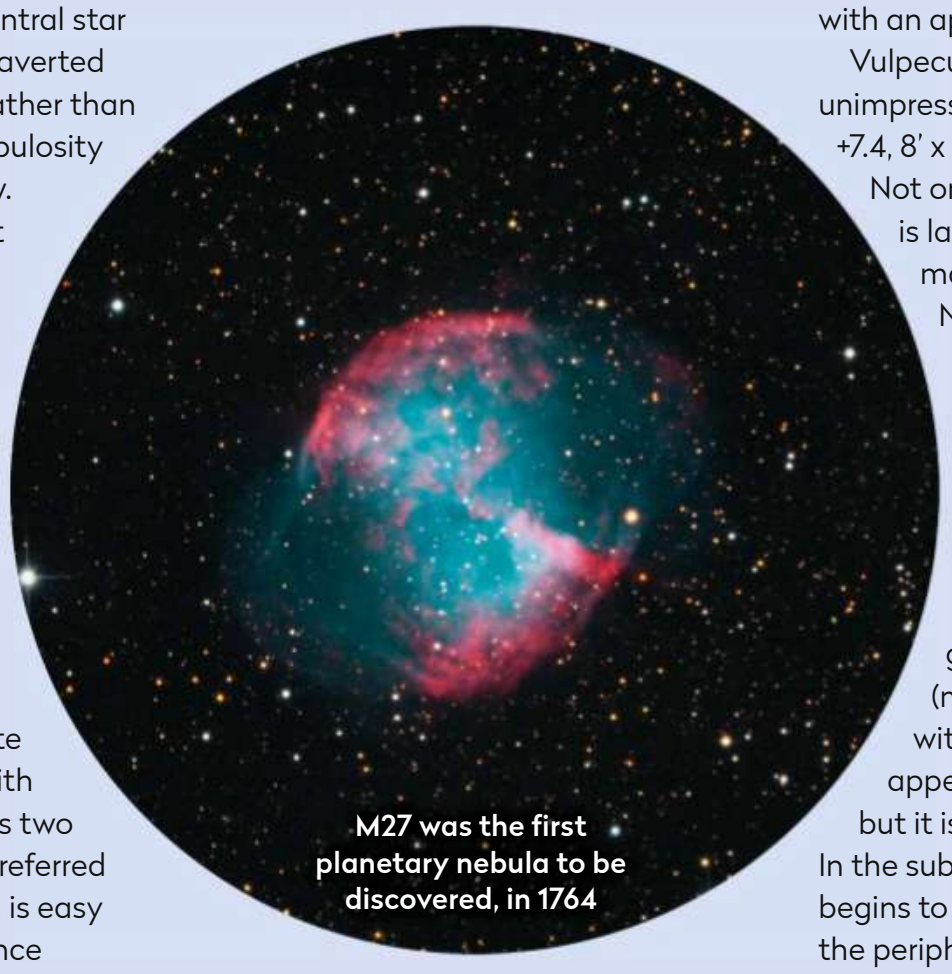
Cygnus, the Swan

Near midnight, the Swan rides high with her companions the Little Fox and Dolphin

One of the best planetary nebulae, **NGC 6826** (mag. +8.8, 8′24″ across), the Blinking Planetary, is located not far from the tip of Cygnus's western wing. Even with a 100mm telescope, under light-polluted conditions it is impossible to see the round nebulae or its mag. +10 central star using direct vision. But practice averted vision – looking off to the side rather than directly at it – and the round nebulosity around the star springs into view. Alternate rapidly between direct and averted vision and the nebulosity blinks on and off.

Cygnus is home to two open star clusters. **M29** (mag. +6.6, 10′ across) is located near the junction of Cygnus' wings and body. North of M29 by 14°50′, and well away from the body of the Swan, is **M39** (mag. +4.6, 31′ across).

The legendary Veil Nebula (**NGC 6992/6960**) is two separate arcs of nebulosity, only visible with an OIII filter. The first of the Veil's two nebulous arcs, NGC 6960, often referred to as the Witch's Broom Nebula, is easy to locate without a computer since this 3°30′ x 2°40′ streak of gas passes through a bright, mag. +4.2 star 52 Cygni. Although the given magnitude for the Witch's Broom is +7.0, its large size means its surface brightness is extremely low. The other main component of the Veil, NGC 6992, forms a 3°50′ x 2°40′ arc, 2°30′ northeast of the Witch's Broom. This half of the Veil is referred to as the Bridal Veil Nebula thanks to its intricate, lacy structure. On a good night it can begin to give up significant detail to telescopes with an aperture of 250mm or more.



M27 was the first planetary nebula to be discovered, in 1764

Vulpecula, the Little Fox, is unimpressive, but it is home to **M27** (mag. +7.4, 8′ x 5′36″), the Dumbbell Nebula. Not only is M27 bright and bold, it is large for a planetary nebula, making it one of the best for Northern Hemisphere observers. Lower magnifications reveal substantial detail and make the Dumbbell a great target for smaller telescopes.

The main object of interest in the small constellation Delphinus, the Dolphin, is a globular cluster, **NGC 6934** (mag. +8.8, 8′24″ across). Even with a 300mm telescope, it appears as an unresolved fuzzball, but it is set in a field rich with stars. In the suburbs, a magnification of 187x begins to resolve individual stars around the periphery of the cluster. ▸

ROD MOLLISE, JOHANNES SCHEDLER/CCDGUIDE.COM, MICHAEL BREITE/STEFAN HEUTZ/WOLFGANG RIES/CCDGUIDE.COM, CHARTS BY PETE LAWRENCE

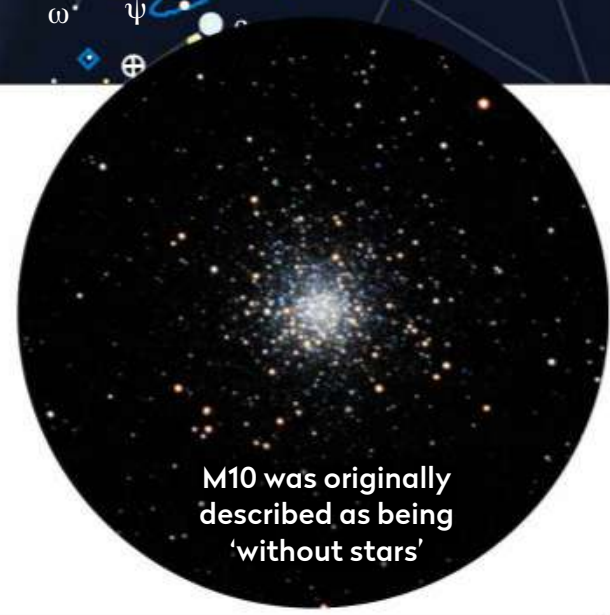
Ophiuchus, the Serpent Bearer

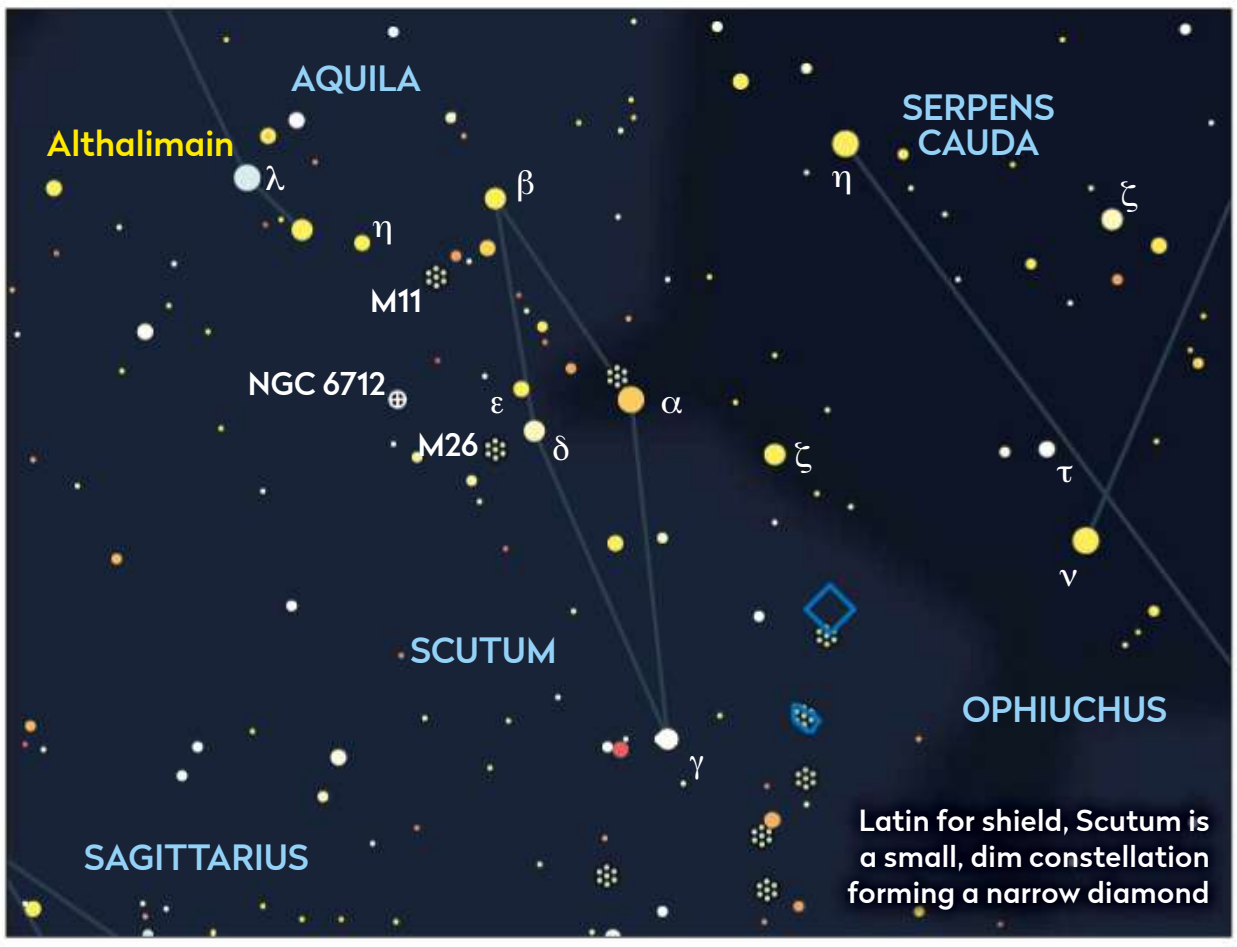
With Serpens, the Serpent, these constellations hold some real gems

Once thought to resemble Asclepius the physician, Ophiuchus looks like a lopsided house drawn by a child. Nevertheless, there are wonders aplenty here.

Ophiuchus's main attractions are globular clusters, beginning with the famed Twin Globs. **M10** (mag. +6.4, 20' across) is a treat. With a 280mm telescope, it is resolved to its core and shows hordes of tiny stars. **M12** (mag. +7.6, 16' across), which lies northwest of M10, is bright and compact, but fewer stars and a looser structure make it appear dimmer than the magnitude figure suggests.

Serpens is actually two constellations, Serpens Caput (the head) and Serpens Cauda (the tail). While the tail is far to the south and doesn't hold much of interest, the head is a different story, containing one of the best globulars visible from northern latitudes: **M5** (mag. +6.6 and 23' across). M5's statistics alone hint at what a spectacle it is. While it is slightly dimmer than M13 and its concentration is about the same, M5 is easier to resolve in any telescope, and is just visible with the naked eye under perfect conditions.


M10 was originally described as being 'without stars'



Latin for shield, Scutum is a small, dim constellation forming a narrow diamond

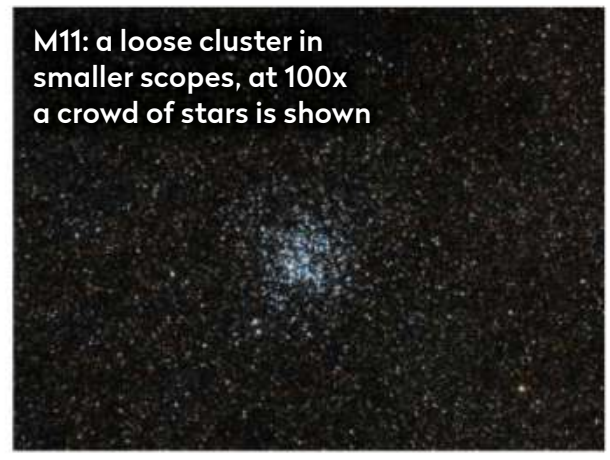
Scutum

Home to one of the prime attractions of the summer sky: the Wild Duck Cluster

M11 (mag. +6.3, 14' across), the Wild Duck Cluster, is a bright open star cluster. As its surface brightness is high, it is easy to make out with a 75mm telescope under poor city skies. Indeed, enough stars should be visible to make clear why this object is the Wild Duck – triangular in shape, suggesting a flight of ducks.

Scutum's other Messier open cluster is **M26** (mag. +8, 10' across), a group of stars whose magnitude and size make it sound like a good catch. However, it turns out to be a major disappointment. A 150mm telescope shows a scattering of at most 10 faint stars and one slightly brighter sun.

Globular cluster **NGC 6712** (mag. +8.7, 2'30" across), just to the east of Scutum's stick figure, isn't anything special in itself, but the field it is set in is incredibly rich – packed with stars, it is almost difficult to tell where the outer stars of the cluster stop and background stars begin. NGC 6712 is visible in the city, and a 300mm telescope may resolve some stars, but its beauty is reduced since the field is no longer as rich with suns as it is from darker skies.


M11: a loose cluster in smaller scopes, at 100x a crowd of stars is shown

▲ Low on the horizon viewed from London, Sagittarius cannot be seen at all from Scotland. Its legs drop down below Corona Australis

Sagittarius, the Archer

Barely above the horizon, this constellation holds a few legends

While the constellation doesn't look anything like the centaur archer of mythology – it looks more like a teapot with a perfect lid and spout –it is home to some bright, legendary objects.

M22 (mag. +5.1, 32' across), the Great Globular in Sagittarius, is an example of an object that makes a visit to the south of England worthwhile. Its highest altitude from the latitude of London is less than 15°, but it is large and easily visible in smaller telescopes. With a 280mm telescope its oval shape becomes evident and its loose central core becomes visible.

Elsewhere, the star cluster **NGC 6530** is loose but attractive, and is composed of about a dozen bright stars. It appears to be embedded in the nebulosity of M8, the Lagoon Nebula, but is thought to actually be a foreground object.

Sagittarius's other famous nebula, **M20** (mag. +6.6, 30' across), the Trifid Nebula, is badly hurt by its low altitude. Despite having a fairly high magnitude and being reasonably large, its faintness is due to the fact that some of the Trifid is reflection nebulosity, which is more difficult to see than emission nebulosity from light-polluted areas.

M20, the Trifid Nebula, is named for its three parts: emission, reflection and dark nebulae

ROD MOLLISE, MARKUS BLAUENSTEINER/CEDIC TEAM/CCDGUIDE.COM, FRANZ KLAUSER/CCDGUIDE.COM, CHARTS BY PETE LAWRENCE

Where are all the aliens?

ROSWELL AT 75

Nick Pope looks at back at the most famous UFO story of all, and why more people are reporting strange sights in the sky

This summer sees the 75th anniversary of the Roswell incident, where believers say an extraterrestrial spacecraft crashed in the New Mexico desert, with debris – and possibly alien bodies – being recovered by the US government, marking the beginning of a decades-long cover-up. What really happened, and why does this mystery still attract such interest and controversy, decades later?

On 24 June 1947, a pilot, Kenneth Arnold, was flying over the Cascade Mountains of Washington State in the US, helping to search for a crashed military aircraft. He saw nine crescent-shaped objects flying in formation at a height of around 3km (10,000ft) and an estimated speed of approximately 1,900km/h: seemingly impossible at the time. Arnold described the jerky movement of the objects as being, "...like a saucer would if you skipped it over water".

The mystery begins

The media got hold of the story, coined the phrase 'flying saucer' and a modern mystery was born. It wasn't the first sighting of what we now call a UFO (unidentified flying object), but it was the first to capture the public imagination, making news headlines around the world. More reports were received, suggesting these sightings were commonplace but had previously gone unreported. As this 'summer of the saucers' progressed, media coverage intensified to a point of near-hysteria, until matters came to a head and it seemed the mystery might be resolved.

On 7 July a local rancher named 'Mac' Brazel contacted the sheriff in Roswell to say he'd discovered strange debris spread over the ranch. He'd found it days earlier but hadn't thought much of it until the stories about flying saucers. Thinking there might be a connection and guessing something might have crashed during a recent storm, he alerted the authorities. He'd brought some samples of the debris, and when the sheriff contacted the nearby Army airbase, intelligence officer Jesse Marcel went to the crash site with Brazel and recovered more debris.

The military base's public information officer, Walter Haut, worked with a local journalist to release a newswire report about the event:

"The many rumors regarding the flying disc became a reality yesterday when the intelligence office of the 509th Bomb Group of the Eighth Air Force, Roswell Army Air Field, was fortunate enough to gain possession of a disc through the cooperation of one of the local ranchers and the sheriff's office of Chaves County.

"The flying object landed on a ranch near Roswell sometime last week. Not having phone facilities, the rancher stored the disc until such time as he was able to contact the sheriff's office, who in turn notified Major Jesse A Marcel of the 509th Bomb Group Intelligence Office.

"Action was immediately taken and the disc was picked up at the rancher's home. It was inspected at the Roswell Army Air Field and subsequently loaned by Major Marcel to higher headquarters." ▸

▼ Stranger things: since the Roswell incident, bizarre UFO-related stories have emerged from across the world, including the alien abduction of cattle

STELLAMC/ISTOCK/GETTY IMAGES, BHAMMOND/ALAMY STOCK PHOTO

Life, but not as we know it: Roswell continues to celebrate its historic link with UFOs

Leased Wire
Associated Press

Roswell Daily Record

RECORD PHONES
Business Office 2288
News Department
2287

Movies as Usual

GRAND

Claims Army Is Stacking Courts Martial

Indiana Senator Lays Protest Before Patterson

RAAF Captures Flying Saucer On Ranch in Roswell Region

House Passes Tax Slash by Large Margin

Defeat Amendment By Demos to Remove Many from Rolls

Security Council Paves Way to Talks On Arms Reductions

No Details of Flying Disk Are Revealed

Roswell Hardware Man and Wife Report Disk Seen

Ex-King Carol Weds Mme. Lupescu

Former King Carol of Rumania and Mme. Elena Lupescu relax aboard the S. S. America bound for Cuba and Mexico in May, 1941. A member of Carol's household in Rio de Janeiro said the ex-king and his companion for 23 years in reign and exile were recently married at their hotel Copacabana Palace suite. (AP Wirephoto).

Some of Soviet Satellites May Attend Paris Meeting

Roswellians Have Differing Opinions On Flying Saucers

American League Wins All-Star Game

Miners and Operators Sign Highest Wage Pact in History

► The news sent shockwaves around the world, but it's the iconic front page headline of the local *Roswell Daily Record* (right) that's best-known: 'RAAF Captures Flying Saucer on Ranch in Roswell Region'.

Within 24 hours there was a stunning development. In a complete reversal of their position, the US military said a mistake had been made, and that the 'flying saucer' was a crashed weather balloon. The *Roswell Daily Record* printed a follow-up story that read 'Gen. Ramey Empties Roswell Saucer' – General Roger Ramey being the Commander of the Eighth Air Force, to whose Fort Worth headquarters the debris had been flown. A series of photos were published showing Ramey, Marcel, and other military personnel holding some of the debris. Sure enough, it looked pretty uninspiring and was entirely consistent with the 'tinfoil' mentioned by the military in their explanation.

Nowadays, with the 24/7 news cycle, internet, social media and an activist community of UFO researchers, such a claim – followed by such an about-turn – would no doubt cause controversy and conspiracy theories on a massive scale. This is especially true given that the 509th Bomb Group was the only atomic bomb-capable squadron anywhere in the world at the time. It's hard to imagine these elite personnel – many of whom were familiar with weather balloons – being fooled in this way. But post-war America was very different from today, and in that calmer, more trusting-of-authority era, the weather balloon explanation was almost universally believed. While interest in flying saucers and UFOs went from strength to strength, Roswell disappeared from the narrative.

A voice from the past

The story of the Roswell UFO crash was rediscovered in 1978 by nuclear physicist-turned-ufologist Stanton T Friedman, who was tipped off that a retired military man had an interesting story to tell: none other than Jesse Marcel. Marcel told Friedman the weather balloon explanation had been a cover story and that the photos had been staged, with weather balloon debris being substituted for the real wreckage. He claimed that everyone involved in the retrieval was clear the object had indeed been an extraterrestrial spaceship.

Over the next few years, researchers dug deeper into the mystery, tracking down many of the key

▲ Breaking news: in July 1947, the *Roswell Daily Record* generated a media frenzy about a 'flying saucer' captured by the US military

◄ After saying that a mistake had been made about the capture, the US military released photos, like this one of Major Jesse A Marcel at Fort Worth, showing pieces of a foil-lined material...

◄ ...and it claimed the wreckage was in fact from a weather balloon.

This picture shows a weather balloon being used in military tests in July 1947 at Forth Worth, five days after the Roswell UFO incident

US GOVERNMENT X 3, STEPHEN FAULKNER/ALAMY STOCK PHOTO, MOVIESTORE COLLECTION LTD/ALAMY STOCK PHOTO

'UFO Trail': a sign in Rendlesham Forest, Surrey, lists a UFO sighting near two military bases in 1980

The UK's X-Files?

The British government once played its own part in investigating strange objects in the night sky

Between 1953 and 2009 the UK's Ministry of Defence researched and investigated UFO reports to assess defence implications. Investigations involved interviewing witnesses, checking radar tapes, analysing photos and videos and cross-checking against military activity, weather balloon launches, satellite paths, meteor showers and more besides. Most sightings turned out to be misidentifications of ordinary phenomena, but around 5 per cent remained unexplained, including sightings from pilots and cases where UFOs were tracked on radar, performing seemingly impossible speeds, manoeuvres and accelerations.

In recent years the MoD has declassified and released nearly 60,000 pages of UFO documents. The most bizarre case in these real-life X-Files was the Rendlesham Forest incident of December 1980, near two military bases in Suffolk. An object briefly landed in the nearby forest, leaving indentations in the frozen ground, scorch marks on the sides of trees and radiation levels assessed by MoD scientists as being "significantly higher than the average background". Another was a highly-classified intelligence study that suggested some sightings might be attributable to a previously-unknown atmospheric plasma phenomenon.

In June 2021 the US government published an intelligence assessment stating that UFOs "clearly pose a safety of flight issue and may pose a challenge to US national security". By then the UK, which wasn't consulted on the US study, had terminated its own investigations and it declined to re-engage on the subject.

As the US government continues to investigate, it seems the truth may be out there – but the UK government won't be finding it anytime soon.

Hoax: the story behind the infamous 'Alien Autopsy' video of 1995...

..underwent a comedy treatment in 2006, in a movie starring Ant and Dec

players, locating additional witnesses and trying to piece together what happened. A number of retired military personnel who'd been based at Roswell corroborated some elements of the crashed spacecraft narrative and added their own details. Sceptics argued that they were simply telling the researchers what they wanted to hear, writing themselves into the story either as a prank, or because they were seeking attention. Either way, books were written, documentaries, drama series and a movie were made, and the idea of a UFO crash became so embedded in pop culture that even if people had no particular interest or belief in UFOs, there was a good chance they had heard of Roswell.

The stuff of legend

By now fact and fiction were getting blurred, and the narrative was incorporating other UFO conspiracies. It was claimed, for example, that the wreckage had been taken to Area 51 (a remote facility in the Nevada desert where the US developed and test-flew aircraft like the U-2, the SR-71 Blackbird, and stealth fighters and bombers), where attempts were made to reverse-engineer the alien craft. Such storylines would subsequently turn up as plots in movies like *Independence Day* and TV shows like *The X-Files*.

In 1995 a video emerged purporting to show an 'alien autopsy' which, it was implied, was connected to Roswell. The film was a fake, of course, but it generated international news, with the hoax footage subsequently forming the basis of a comedy film starring TV presenters Ant and Dec.

During the 1990s the US government succumbed to media and public pressure, launching their own ▸

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Area 51, the secretive US military facility that is the subject of many alien conspiracy theories

PETER GRIFFIN/ALAMY STOCK PHOTO, FRANCK MARCHIS/SETI, IAN DAGNAL/ALAMY STOCK PHOTO, ZUMA PRESS, INC./ALAMY STOCK PHOTO, US GOVERNMENT

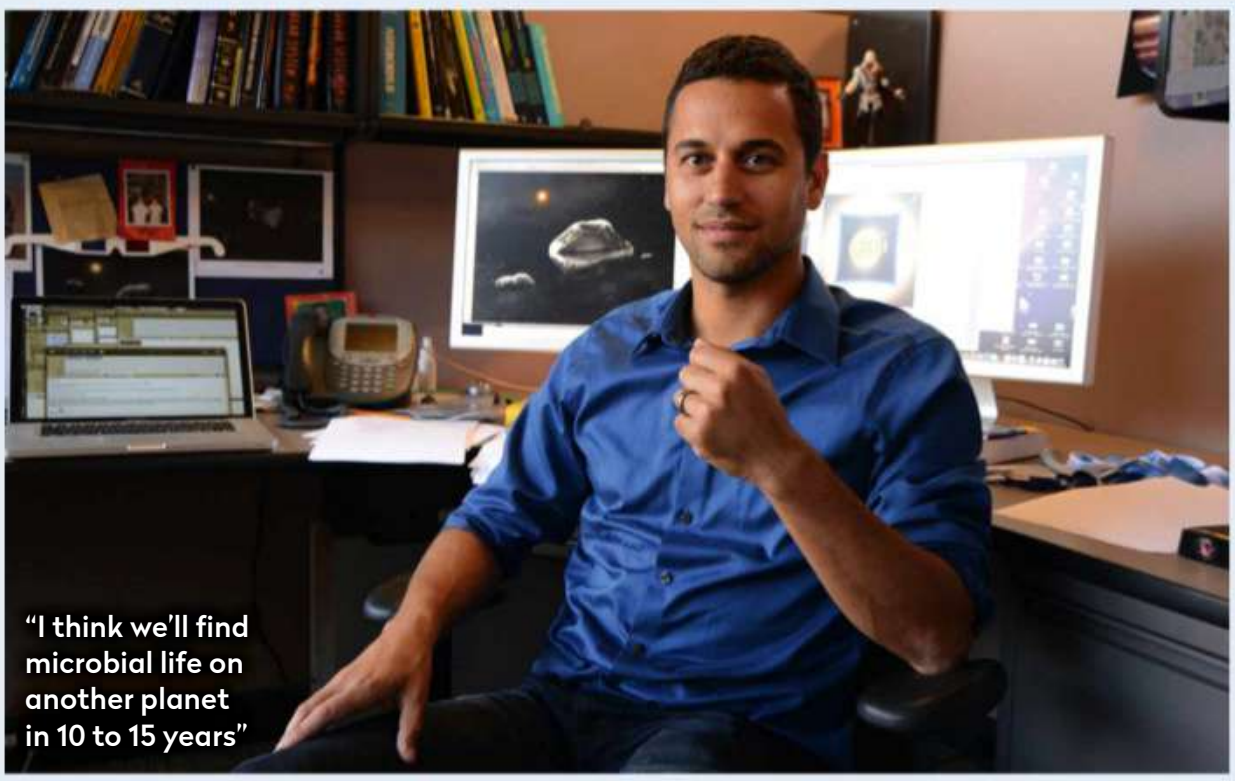
▸ retrospective investigation and publishing two reports, the first in 1994 and the second in 1997. The conclusion was that the culprit was indeed a high-altitude weather balloon, but that it had been carrying equipment designed to search the atmosphere for evidence of Soviet nuclear tests as part of something called Project Mogul. Sceptics say the highly-classified nature of this monitoring project explains any apparent oddities in the handling of the incident. It's even possible that the flying disc story was a local initiative designed to throw the media off the true story, with higher command subsequently overruling the plan and saying it was a weather balloon.

The second government report, the release of which coincided with the 50th anniversary of the incident, was arguably guilty of over-egging the pudding. None of the original reports had mentioned alien bodies, and even Jesse Marcel denied this

The Search for Extra-Terrestrial Intelligence

Franck Marchis of the SETI Institute reveals how scientists search for intelligent life beyond Earth

"The SETI Institute is a non-profit organisation of astronomers, biologists, philosophers: anyone searching for intelligent life in our Universe. We search for technosignatures that could be coming from an advanced civilisation. Imagine one that knows we are here and beams lasers to send us messages. It may take a hundred years for us to receive it, but that's the kind of signal we want to detect.


"I think we'll find microbial life on another planet in 10 to 15 years"

"Maybe intelligence, technological intelligence, is not supposed to live for a long time. But if we find an intelligent civilisation, we'll know that we – a biological and technological species – have a future. We would have someone to talk to, to exchange information with.

"I love the Roswell story. It's the start of modern UFO lore. Today, anyone can record a video in seconds on a smartphone, so we have multiple recordings of weird things happening in the sky. There is a movement now in SETI to create a group to analyse this footage, or even collect new data. There is something strange happening in the sky, because people are recording it, so let's study this using the scientific method.

"We've only just begun the search for intelligent life. There are 400 billion stars in our Galaxy, and 3 trillion galaxies in the Universe, so it will take a long time.

"I think we'll find microbial life on another planet in 10 to 15 years, but I'm betting that we'll soon find a radio candidate, one that's identical to Earth in terms of chemistry. And scientists will argue that this planet has life like ours."

▸ For more on SETI, visit seti.org

More **ONLINE**

Turn to page 5 to watch our full interview with Franck Marchis

▲ Otherworldly: Roswell has embraced its alien associations, with a UFO Museum (above); and its annual UFO-themed parades (right)

aspect of the story, which only emerged later. But the United States Air Force felt they had to address the issue and their convoluted theory suggested that people had conflated the 1947 crash with tests in the 1950s, in which anthropomorphic crash test dummies had been dropped to test the efficacy of military parachutes. Even for neutral recipients, this was a stretch, and was met with predictable derision.

By this time, however, the story of Roswell had become the UFO community's flagship case. The city of Roswell had embraced its heritage, a UFO museum had been opened and annual events were held to mark the occasion. Roswell now has such name recognition that several US presidents have alluded to the UFO incident in speeches and interviews, usually making light-hearted quips, but sometimes – seemingly – playing it sufficiently straight to make people wonder.

Is the truth out there?

Fast forward to the present day. The topic of UFOs has been steadily transitioning from fringe to mainstream over the last few years – at least in the US. This process started in December 2017 with two related scoops from *The New York Times*: firstly, the revelation that the US Navy had videos of UFOs taken from some of its fast jets, and secondly, the existence of the Advanced Aerospace Threat Identification Program (AATIP). The exact role of AATIP is still the subject of dispute, but the Pentagon confirmed that it did – in part – study UFO data. This is significant because previously the US government said that official interest in the topic ceased at the end of 1969, when an old Air Force program, Project Blue Book, had been terminated.

The New York Times story was seized upon by Congress, and classified briefings followed, with a number of high-profile politicians – Republicans and Democrats alike – speaking out on the issue. In summer 2021 the Office of the Director of National Intelligence published an inconclusive preliminary assessment that stated most of the sightings studied remained unexplained. More recently, multiple UFO-related provisions were included in the Defense Bill, requiring the Department of Defense, the military and the intelligence community to work together to resolve the mystery. Congress wants to know if these mystery objects are drones operated by an adversary such as Russia or China, or something else. Seemingly, nothing has been taken off the table, and this has sent the UFO community into a predictable frenzy.

All this means that the 75th anniversary of the Roswell incident is significant. It isn't just an opportunity for the local community to put on its usual parade and conference. Rather, Roswell is in the spotlight again, representing a sort of 'ground zero' of the UFO phenomenon. As the event passes from living memory into history, we may never resolve the mystery, but the story speaks to our wider fascination with one of the biggest and most profound questions we can ask: whether or not we're alone in the Universe.

▼ Close encounter: a video taken by US Navy jet pilots from *USS Theodore Roosevelt*, in 2015, appears to show a mysterious flying object that is rotating

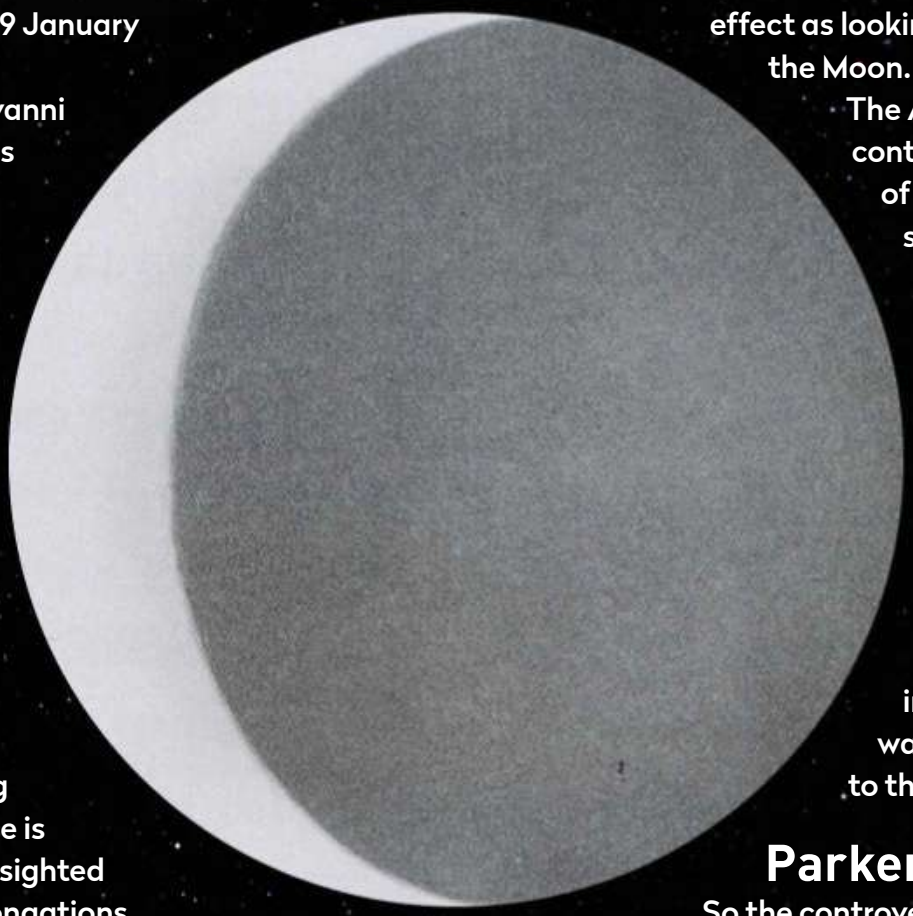
Nick Pope worked for the Ministry of Defence for 21 years. From 1991 to 1994 his duties included investigating UFO sightings to assess national security implications

VENUS
in a new light

Has the Parker Solar Probe solved the mystery of the Ashen Light? **Paul G. Abel** assesses the evidence

On the evening of 9 January 1643, the Italian astronomer Giovanni Riccioli turned his telescope on to the planet Venus and, in doing so, ignited a mystery that has persisted until the present day. Riccioli was able to observe a dull glow coming from the night side of Venus – a phenomenon called 'the Ashen Light'.

The Ashen Light is only visible when Venus is in the crescent stage and observed in a dark sky. When present, some (or sometimes all) of the night side of Venus is seen to be glowing with a greyish light. Its appearance is unpredictable, and it seems to be sighted more when Venus is at eastern elongations and visible as an evening star. Over the years, the Ashen Light has been recorded by a number reliable observers – Patrick Moore observed the phenomenon many times and described the effect as looking similar to earthshine on the Moon.



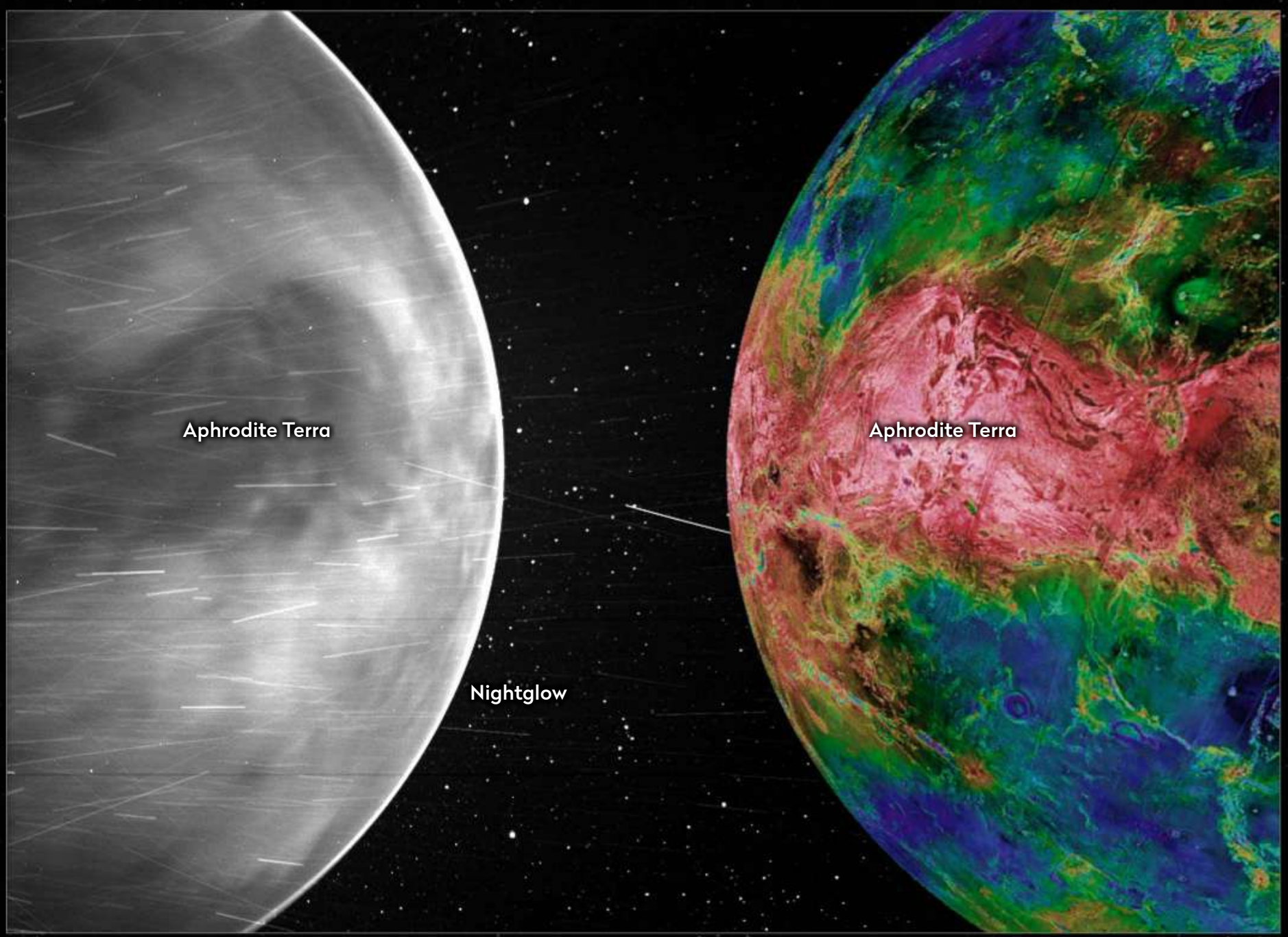
▲ Patrick Moore's drawing of the Ashen Light on 27 May 1980

The Ashen Light is a somewhat controversial topic – those in favour of it point out that it has been seen by multiple independent observers who reported very similar details. Those who think the Light is an illusion point out that the phenomenon has never been imaged at the same time as a visual sighting. Of course, by the time Venus is a crescent, it is low in the sky and many imagers concentrate on infrared or ultraviolet images, wavelengths which are not visible to the human eye.

Parker space

So the controversy has persisted without any resolution. Until this earlier year when, on 9 February, NASA announced some interesting results from the Parker Solar Probe. The spacecraft made flybys of Venus on 11 July 2020 and 20 February 2021, and used

NASA, GWENGOAT/ISTOCK/GETTY IMAGES, SIR PATRICK MOORE HERITAGE TRUST/ COURTESY OF THE EXECUTORS, NASA/APL/NRL, MAGELLAN TEAM/JPL/USGS



▲ Comparing Parker's image on the left with the radar returns from NASA's Magellan probe, which launched in 1989 and orbited Venus with the intent of creating a map of its surface. The high ground, Aphrodite Terra, coincides with the dark area seen by Parker

"These results from NASA's Parker probe show conclusively that the night-side surface can be seen in optical wavelengths"

its wide-field imager (WISPR) to image the night side of Venus in visible wavelengths and near-infrared.

Astronomers realised that the resulting images of the night side showed a lot of surface detail, with large plains and plateaus clearly visible. For the first time, the glowing surface on the night side of Venus had been observed at optical wavelengths. A bright nightglow emission from oxygen atoms high in the atmosphere was also seen at the planet's limb.

Could this discovery be the solution to the Ashen Light mystery? These results from NASA's Parker probe show conclusively that the night side surface can be seen in optical wavelengths. If there are active volcanoes on Venus (and a number of astronomers agree this is likely, myself included) then perhaps during times of heightened activity, the increased surface heat combined with any thinning of the clouds might allow the night-side surface of Venus to be perceived with Earth-based telescopes. This could explain why observations of the Ashen Light are often reported as a patchy glow covering just parts of the night side.

In spite of this recent discovery, we still don't yet have 'the smoking gun'. What we really need is a visual observation of the Ashen Light and an image of the phenomenon taken at the same time. Venus will next be in the crescent stage in June 2023 – this will be a good time for us all to observe Venus and see if we can, once and for all, attempt to both see and image the Ashen Light, and finally solve a mystery which has lasted for nearly four centuries.

▶ For more about the Parker Solar Probe's mission, see page 60

Paul G. Abel is Director of the British Astronomical Society's Mercury and Venus section. He is a theoretical physicist at the University of Leicester

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BBC Sky at Night MAGAZINE

16-PAGE CENTRE PULLOUT

The Sky Guide

JULY 2022

2022'S LARGEST FULL MOON

Catch a bright Moon just after perigee, when it's closest to Earth in its orbit

PETE LAWRENCE

SPACE ROCK

Observe Asteroid 14 Irene as it reaches opposition

PEAK PERFORMANCE

Enjoy the Southern Delta Aquariids meteor shower

About the writers

Astronomy expert **Pete Lawrence** is a skilled astro imager and a presenter on *The Sky at Night* monthly on BBC Four

Steve Tonkin is a binocular observer. Find his tour of the best sights for both eyes on page 54

Also on view this month...

- The 'Moonwatch' ray crater Kepler
- Noctilucent cloud displays
- Track and capture the dwarf planet Pluto

Red light friendly

To preserve your night vision, this Sky Guide can be read using a red light under dark skies

Get the Sky Guide weekly

For weekly updates on what to look out for in the night sky and more, sign up to our newsletter at **www.skyatnightmagazine.com**

JULY HIGHLIGHTS

Your guide to the night sky this month

All Month

Noctilicent cloud season runs from late May through to early August, July being an excellent month to look out for these elusive high-altitude ice clouds.

Monday 4

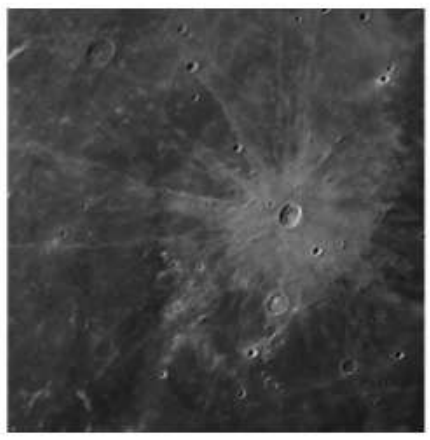
Happy aphelion day! Earth reaches the point in its year-long orbit when it is farthest from the Sun today.

Wednesday 6

Minor planet 14 Irene reaches opposition today, at the eastern edge of the handle of the Teapot asterism in Sagittarius. Shining at mag. +9.8, it'll be tricky to identify Irene's star-like dot against the backdrop of Milky Way.

Saturday ▶ 9

Our 'Moonwatch' target, the ray crater Kepler, is well presented tonight and tomorrow night. A second opportunity occurs during the Moon's waning phase on the mornings of 23 and 24 July. See page 52.



Wednesday ▶ 13

Today's full Moon occurs at 19:38 BST (18:38 UT) just 9hrs 29m after lunar perigee (10:09 BST (09:09 UT)), the point in the Moon's orbit when it's closest to Earth. This is the smallest gap for 2022, making this the best perigee full Moon of 2022.

Friday 15

As this evening's 92%-lit waning gibbous Moon rises around 23:30 BST (22:30 UT), look out for mag. +0.5 Saturn 4.8° above it.

PETE LAWRENCE X 8

◀ Friday 22

Mag. +0.3 Mars and a 36%-lit waning crescent Moon sit above the east-northeast horizon, separated by 4°. Both objects are visible from 00:40 BST (23:40 UT on 21 July). Mag. +5.8 Uranus also lies 2.3° east of the Moon.

Saturday 23

The 26%-lit waning crescent Moon lies 4.4° south of the Pleiades open cluster this morning. See them both above the east-northeast horizon from 02:00 BST (01:00 UT).

Friday 29

Saturn forms a triangle with Deneb Algiedi (Delta (δ) Capricorni) and Nashira (Gamma (γ) Capricorni).

Mercury and a 1%-lit waxing crescent Moon are 3° apart this evening.

Saturday ▶ 30

A thin 4%-lit Moon is 9°from mag. –0.6 Mercury 30 minutes after sunset.

The peak of the Southern Delta Aquariids meteor shower. See page 47 for details.

Friday ▶

8 A view of the Moon through binoculars or a telescope this evening will reveal the illuminated arc of the Jura Mountains curving into darkness at the Moon's terminator. This Jewelled Handle clair-obscur effect is at its best around 23:10 BST (22:10 UT).

Sunday ▶

10 This evening the 88%-lit waxing gibbous Moon sits 2.2° from red-supergiant Antares (Alpha (α) Scorpii). Catch them at their closest around midnight, low above the southwest horizon.

Tuesday

19 Mag. –2.4 Jupiter appears 2.9° above a 65%-lit waning gibbous Moon in the early hours.

Thursday

21 July is a tricky month for deep sky observing due to the brightness of the night sky at the start of the month. From now until the end of July is the best time to attempt our 'Deep Sky Tour' on page 56, as the Moon will be out of the way.

Tuesday

26 Mag. –3.8 Venus appears in the early morning sky, near to a beautiful 5%-lit waning crescent Moon. Catch them at their best from 04:00 BST (03:00 UT).

Wednesday

27 Mag. –3.8 Venus appears in the early morning sky, near to a beautiful 2%-lit waning crescent Moon. Catch them at their best from 04:00 BSTzz (03:00 UT).

Thursday

28 With the Moon new today, this is a great time to try and track down eighth magnitude comet C/2017 K2 (PanSTARRS), which has been moving south through Ophiuchus, the Serpent-Bearer, this month.

Family stargazing

Noctilucent clouds (NLCs) are excellent targets for youngsters to look out for. Typically seen 90–120 minutes after sunset low above the northwest horizon, or a similar time before sunrise low above the northeast horizon, they just require a flat, clear horizon and keen eyes. They shine with a white/blue-white colour and have a fine wispy structure. Any regular clouds in the area will appear dark against NLCs – high altitude ice-sheet clouds, which are so high that they can reflect sunlight at night even though the Sun is below the horizon for us on the ground. **bbc.co.uk/cbeebies/shows/stargazing**

NEED TO KNOW

The terms and symbols used in The Sky Guide

Universal Time (UT) and British Summer Time (BST)
Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT

RA (Right ascension) and dec. (declination)
These coordinates are the night sky's equivalent of longitude and latitude, describing where an object is on the celestial 'globe'

Family friendly
Objects marked with this icon are perfect for showing to children

Naked eye
Allow 20 minutes for your eyes to become dark-adapted

Photo opp
Use a CCD, planetary camera or standard DSLR

Binoculars
10x50 recommended

Small/ medium scope
Reflector/SCT under 6 inches, refractor under 4 inches

Large scope
Reflector/SCT over 6 inches, refractor over 4 inches

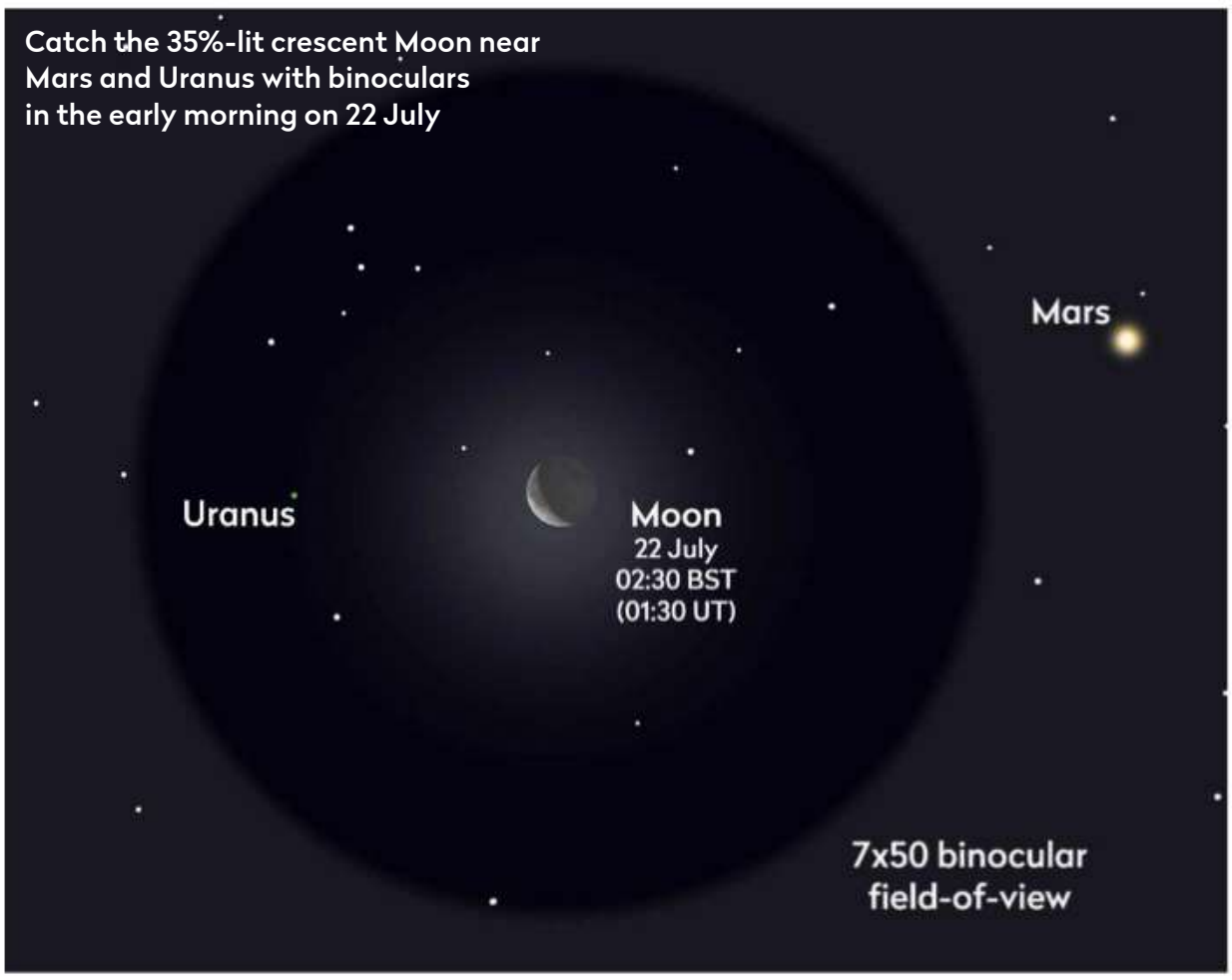
GETTING STARTED IN ASTRONOMY

If you're new to astronomy, you'll find two essential reads on our website. Visit **http://bit.ly/10_easylessons** for our 10-step guide to getting started and **http://bit.ly/buy_scope** for advice on choosing a scope

DON'T MISS

Thin Moons and planets

BEST TIME TO SEE: 15/16, 17/18, 19, 21, 26 and 27 July at times specified



Catch the 35%-lit crescent Moon near Mars and Uranus with binoculars in the early morning on 22 July

The Moon circumnavigates the night sky once every 27.321 days, never straying far from the ecliptic. The main planets in the Solar System also tend to remain close to the ecliptic and consequently, the Moon makes a pass of each one every month.

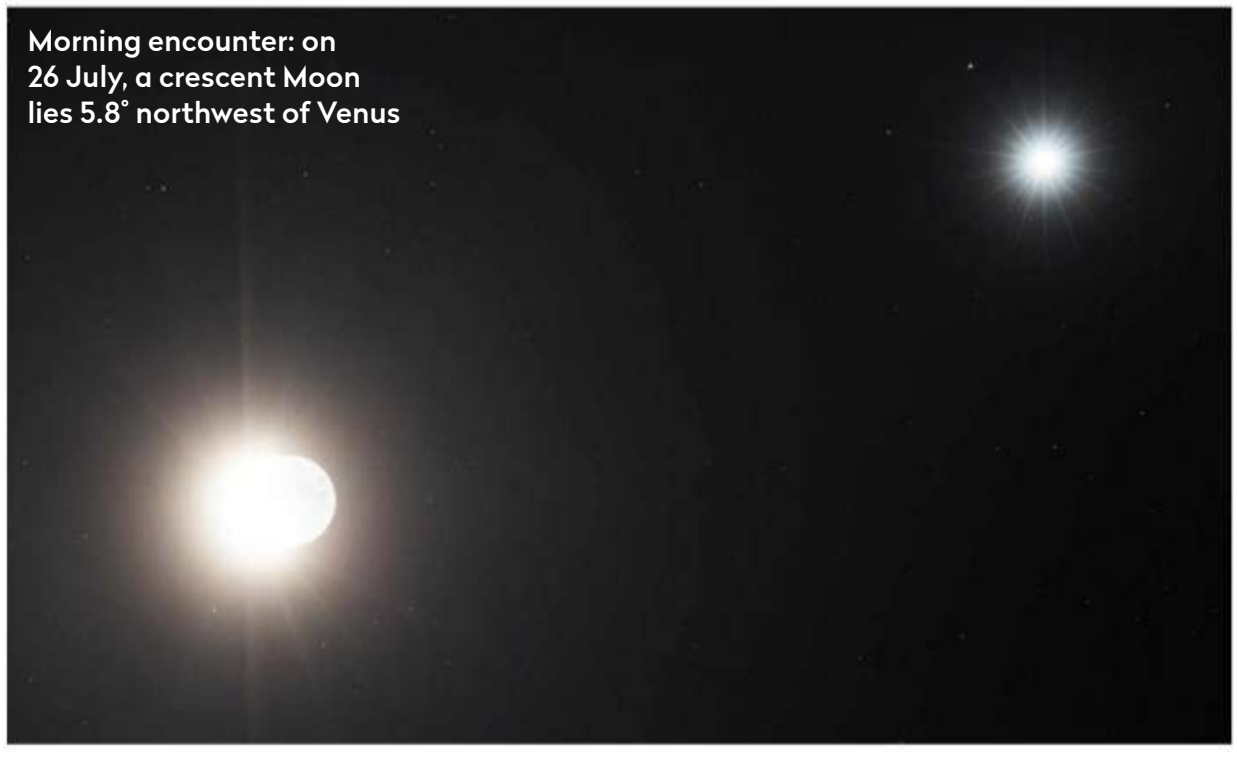
This month's encounters are in the morning sky with Saturn up first. Approaching opposition on 14 August, Saturn is currently in eastern Capricornus. It encounters a 92%-lit waning gibbous Moon on 15/16 July, the Moon passing 5° south of the planet. On the night of 17/18 July it's Neptune's turn, although this dim mag. +7.9 planet will be tricky to see against the light from a 76%-lit waning gibbous Moon, which lies 4.2° to its south.

There's no problem spotting Jupiter near the Moon on the morning of 19 July. Shining at mag. –2.4, the gas giant appears 2.8° north of the Moon's centre at 03:30 BST (02:30 UT) on 19 July. If the day ahead is clear, try and stick with the pair after sunrise. They are due south at 06:00 BST (05:00 UT) with an altitude of 35°.

Mars is next and its encounter gives a tantalising taste for what's to come later in the year. On the morning of 21 July Mars lies in the Moon's direct path, 6.2° to the west. As the day progresses, the gap reduces so that by the time they are approaching their setting point, they will be just 2° apart. Shining at mag. +0.3, Mars will be a tricky daylight target. If there were no horizon, we'd see the Red Planet miss the Moon's southern edge by just 3 arcminutes from the UK's centre, even closer from the extreme north of the country. There will be a series of close lunar passes with Mars over the coming months, and the Red Planet will be occulted by a full Moon on 8 December.

The 35%-lit Moon remains close to Mars on the morning of 22 July and even closer to Uranus on this date, 1.9° from the dimmer planet at 03:15 BST (02:15 UT). Uranus appears 22 arcminutes north of the Moon's centre at 07:20 BST (06:20 UT), but at mag. +5.8 under daylight conditions is out of reach. It'll be interesting to try and record it using an infrared sensitive camera at this time, to see whether this is possible.

Finally, on 26 July the 6%-lit waning crescent Moon lies 5.8° northwest of Venus, while on the morning of 27 July, the now 2%-lit waning crescent lies 6.8° to the northeast of Venus. The pair rise above the northeast horizon approximately 80 minutes before sunrise.


Morning encounter: on 26 July, a crescent Moon lies 5.8° northwest of Venus

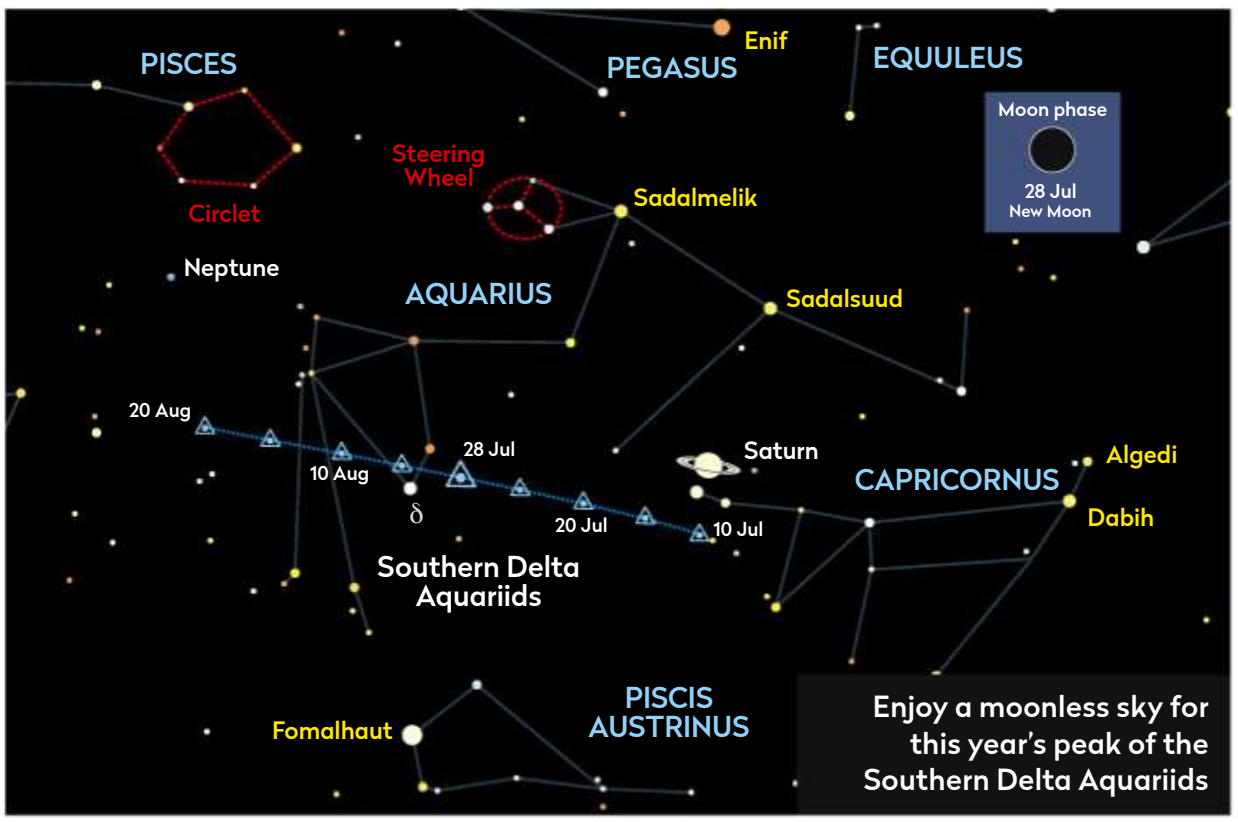
ALL PICTURES: PETE LAWRENCE

Southern Delta Aquariids meteor shower

BEST TIME TO SEE: 28–31 July, midnight BST (23:00 UT) through to 03:00 BST (02:00 UT)

The Southern Delta Aquariids meteor shower peaks on 28–29 July. This year the Moon will be absent from the sky, as it approaches the new phase on the afternoon of 28 July. This leaves the sky dark for Southern Delta meteors. Well, when we say dark, we mean as dark as it ever gets at the end of July! For those in the north of the UK, the sky still carries its characteristic deep blue colour, never reaching proper astronomical darkness at all. Even from the far south of the UK, proper darkness is rather brief.

Don't let this detract you from enjoying the shower though, as bright trails will make themselves known. The Southern Delta Aquariids (SDA) shower is active between 12 July and 23 August, reaching peak activity at the end of July, on the nights of 28/29, 29/30 and 30/31 July. It's well worth observing across all three dates if you can. Peak rates typically reach a zenithal hourly rate (ZHR) of 16 meteors per hour but, as we often state in the 'Sky Guide', ZHRs can be misleading. The ZHR figure represents the number of meteors expected to be seen per hour under perfect viewing conditions with the shower radiant – the region of sky where the shower meteors emanate from – directly above your head. Such conditions are rarely met and this is the case with the SDA, its radiant sited near Skat (Delta (γ) Aquarii), which doesn't get very high from the UK.



Enjoy a moonless sky for this year's peak of the Southern Delta Aquariids

To observe the shower, find somewhere dark and sit or lie back, looking up at the sky; an altitude of 60° (two-thirds up from the horizon) is ideal, in any direction. As the nights are short in July, an all-night watch still allows you to get some sleep after the session.

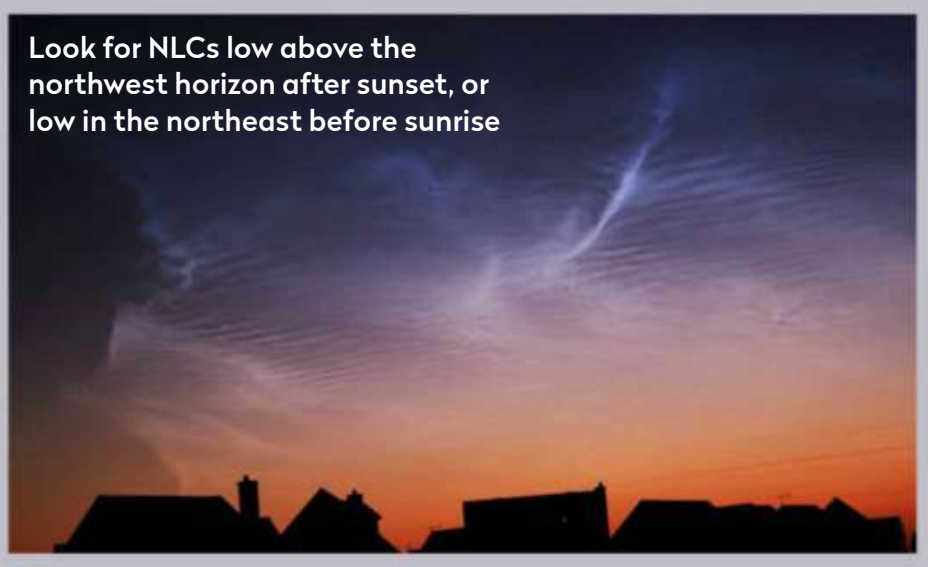
Noctilucent clouds season – part 2

BEST TIME TO SEE: 90–120 minutes after sunset, or at similar time before sunrise

June and July are the best months for spotting elusive noctilucent or night-shining clouds. These are a phenomenon which bridge the divide between space and weather, occurring at an altitude of 82km in the mesosphere. NLCs form as sheets of tiny ice particles, seeded by fragments of meteor dust, the tiny remnants left behind when a meteoroid vaporises in Earth's atmosphere. The temperature of this region of the mesosphere becomes super-cooled in the Northern Hemisphere during its summer, the tiny pieces of meteor dust acting as nuclei for the ice crystals that eventually spread into an NLC sheet.

If present, NLCs are typically seen 90–120 minutes after sunset, low above the northwest horizon, or a similar time low above the northeast horizon before sunrise. Big displays may persist all through the night, moving through north as they track the position of the Sun beneath the horizon.

As they reflect sunlight, NLCs appear bright against the twilight sky, taking on their characteristic attribute of shining at night. Their appearance is distinctive, often exhibiting an electric blue colouration and with fine stranded or herringbone structures. As they sometimes appear bright, they also make superb targets for cameras and may be recorded using modern smartphones.


Look for NLCs low above the northwest horizon after sunset, or low in the northeast before sunrise

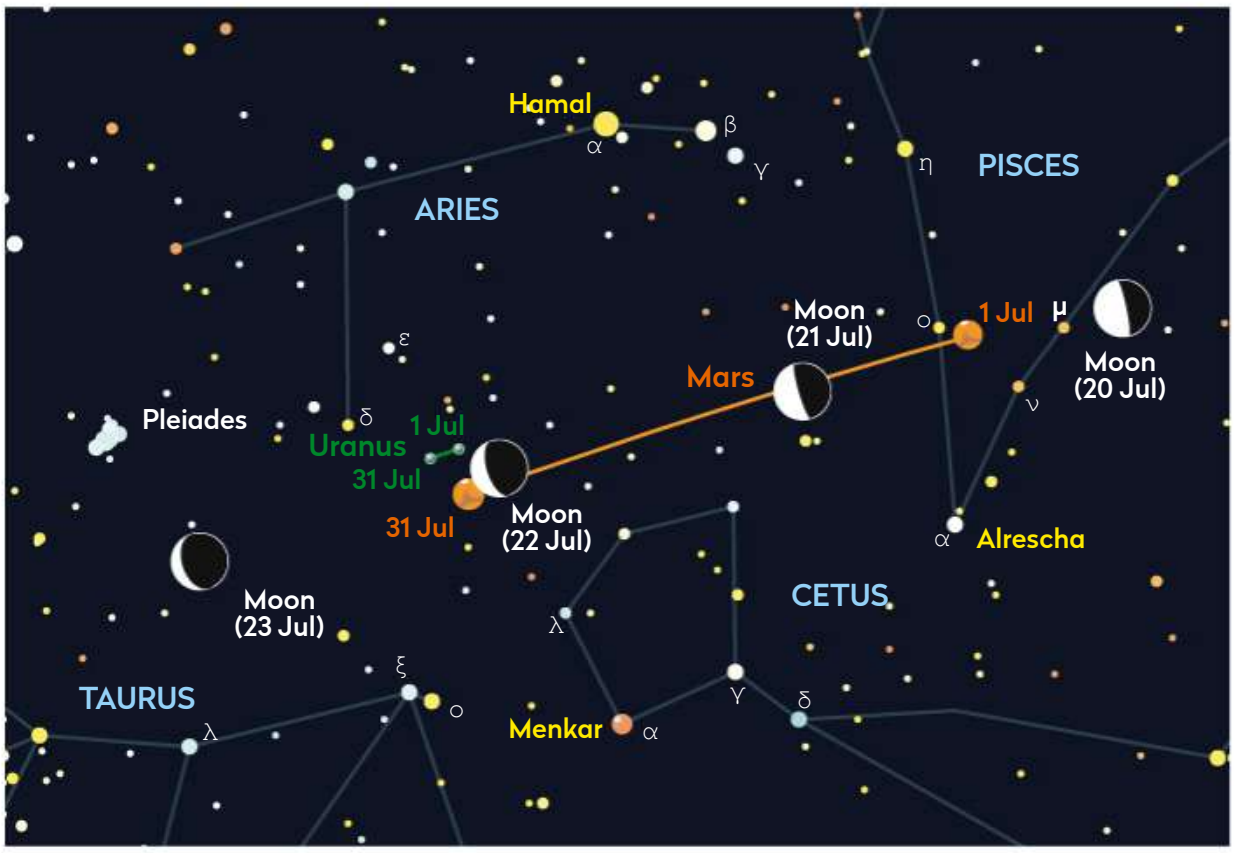
THE PLANETS

Our celestial neighbourhood in July

PICK OF THE MONTH

Mars

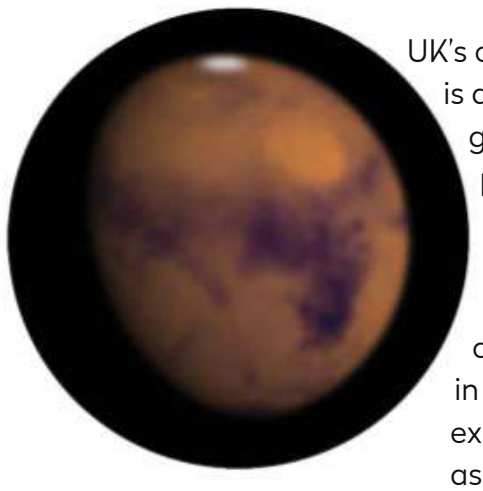
Best time to see: 31 July, 03:30 UT
Altitude: 37°
Location: Aries
Direction: East-southeast
Features: Phase, surface markings, atmospheric phenomena, polar caps
Recommended equipment: 75mm, or larger



▲ Get familiar with views of Mars over July to prepare for the opposition on 8 December

We're less than six months away from the next opposition of Mars on 8 December 2022, and it's around this time that the planet starts to improve noticeably week on week. On 1 July, Mars shines at mag. +0.5 and presents a 7 arcsecond disc when viewed through a telescope's eyepiece. At this time, instruments 200mm or larger will start to reveal surface features, present as dark markings on the planet's globe. In addition, the southern polar cap should be visible as a bright 'spot' on the southern edge of the planet. Mars will appear 85%-lit on 1 July, the planet's southern pole tilted towards Earth by 20°.

By the end of the month, the Red Planet will have brightened slightly to mag. +0.2 and will be presenting an 8 arcsecond disc. The planet's phase will be 84%-lit on 31 July, the southern pole's tilt angle having reduced so that it's inclined to Earth by 14°. This will move the southern pole a bit further away. At this time, increased warming in the planet's southern hemisphere will have had an effect on the pole, its appearance naturally reducing.



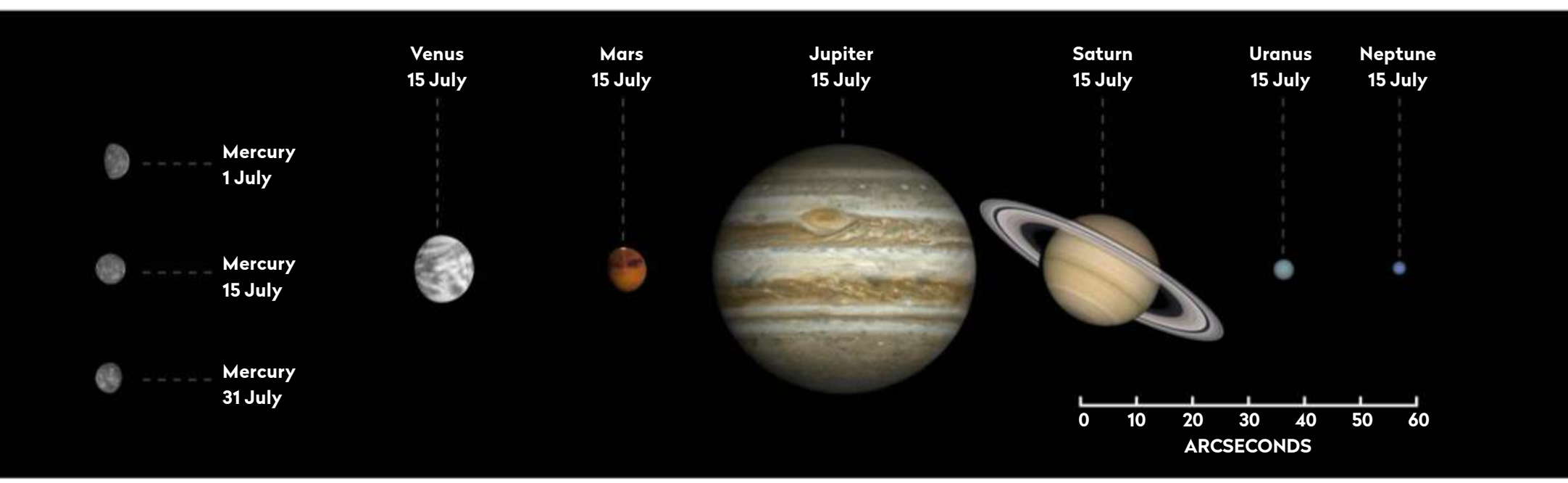
▲ A 200mm or larger telescope will reveal surface features on Mars

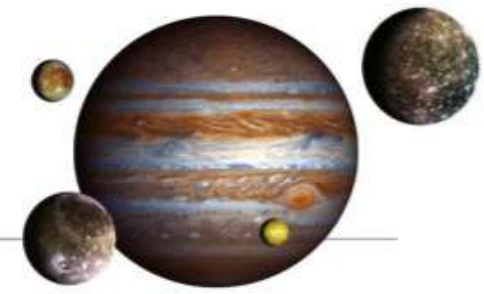
PETE LAWRENCE X 2

On 31 July, Mars is located in the constellation of Aries, the Ram, and able to attain a peak altitude around 21° under dark-sky conditions as seen from the UK's centre. Although low, this is a good time to try and get acquainted with the planet. With increasing dark-sky altitude and a growing apparent size, getting used to the view during July will put you in an excellent place to experience the view of Mars as it approaches opposition in early December. A 35%-lit waning crescent Moon sits 4.5° to the east of Mars on the 22nd. On 31 July, Mars will lie 1.8° from mag. +5.8 Uranus.

The planets in July

The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope





Mercury

Best time to see: 1 July, 30 minutes before sunrise
Altitude: 4° (very low)
Location: Taurus
Direction: Northeast

Mercury is a morning planet at the start of July, brightening as it creeps towards the Sun. On 1 July it shines at mag. –0.7 and rises 70 minutes before sunrise. By the 7th, Mercury brightens to mag. –1.22, but rises only 55 minutes before the Sun. The last date of visibility is probably 12 July, when mag. –1.7 Mercury rises above the northeast horizon, 30 minutes before sunrise.

Superior conjunction is on 16 July, after which it emerges into the evening sky but is poorly placed. On 25 July, mag. –1.0 Mercury sets just 35 minutes after the Sun.

Venus

Best time to see: 31 July, 03:45 UT
Altitude: 9° (low)
Location: Gemini
Direction: East-northeast

Venus is in the morning sky, shining at mag. –3.8. On 1 July it rises 110 minutes before the Sun, increasing to 120 minutes by July's end. Telescopically, Venus appears as a gibbous disc, 90%-lit, 10 arcseconds across. A waning crescent Moon is nearby on the mornings of the 26th and 27th.

Jupiter

Best time to see: 31 July, 03:30 UT
Altitude: 38°
Location: Cetus
Direction: South

Jupiter is a morning planet, but over past weeks its position has been poor, only appearing at low altitude before sunrise. Now we're past the June solstice, the UK's night is lengthening and Jupiter is improving. Jupiter is located in the northwest corner of Cetus, the Whale. Shining at mag. –2.4, it is visited by a 65%-lit waxing gibbous Moon on the morning of 19 July, which sits 3° south of the planet at 02:00 BST (01:00 UT).

Saturn

Best time to see: 31 July, 01:20 UT
Altitude: 22°
Location: Capricornus
Direction: South

Things begin to improve for Saturn this month, as we're past the June solstice. As it approaches opposition on 14 August, Saturn is able to reach its highest position in the sky, due south, in relative darkness from mid-month onwards. A 91%-lit waning gibbous Moon sits below Saturn on the morning of 16 July, the pair rising together around 23:20 BST (22:20 UT) on 15 July.

Uranus

Best time to see: 31 July, 01:30 UT
Altitude: 21°
Location: Aries
Direction: East

A morning planet, improving in position towards July's end.

Neptune

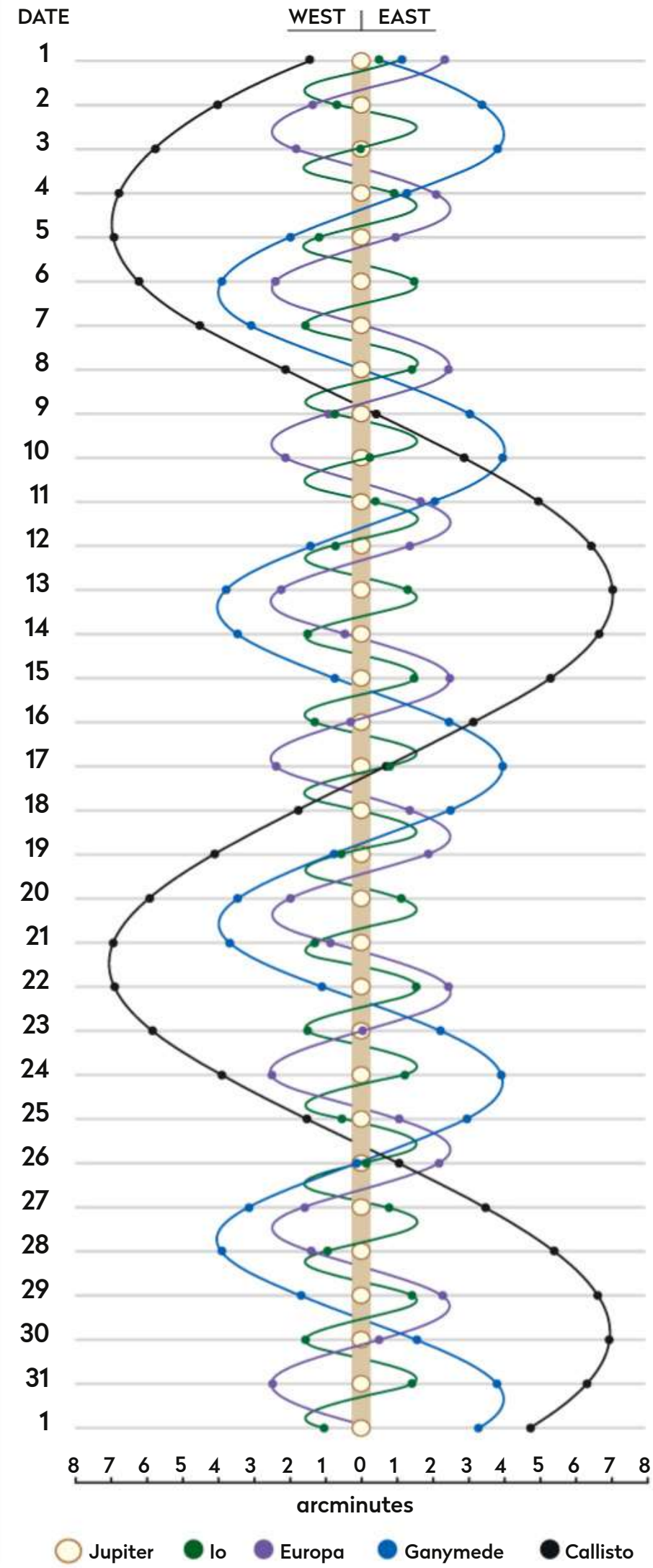
Best time to see: 31 July, 01:30 UT
Altitude: 29°
Location: Pisces
Direction: Southeast

Neptune is poorly located in the morning sky at July's start, a situation which improves rapidly as the nights lengthen. By July's end, Neptune reaches an altitude of nearly 30° under dark skies. Neptune is in Pisces, but this doesn't last for long as it slips back into Aquarius in mid-August.

More ONLINE
Print out observing forms for recording planetary events

JUPITER'S MOONS: JULY

Using a small scope you can spot Jupiter's biggest moons. Their positions change dramatically over the month, as shown on the diagram. The line by each date represents 01:00 BST (00:00 UT.)



THE NIGHT SKY – JULY

Explore the celestial sphere with our Northern Hemisphere all-sky chart

KEY TO STAR CHARTS

- Arcturus — STAR NAME
- PERSEUS — CONSTELLATION NAME
- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- THE MOON, SHOWING PHASE
- COMET TRACK
- ASTEROID TRACK
- STAR-HOPPING PATH
- METEOR RADIANT
- Circlet — ASTERISM
- PLANET
- QUASAR

STAR BRIGHTNESS:

- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER
- COMPASS AND FIELD OF VIEW
- MILKY WAY

When to use this chart

1 July at 01:00 BST
15 July at 00:00 BST
31 July at 23:00 BST

On other dates, stars will be in slightly different positions because of Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

How to use this chart

1. Hold the chart so the direction you're facing is at the bottom.
2. The lower half of the chart shows the sky ahead of you.
3. The centre of the chart is the point directly over your head.

Sunrise/sunset in July*

Date	Sunrise	Sunset
1 Jul 2022	04:46 BST	21:42 BST
11 Jul 2022	04:55 BST	21:35 BST
21 Jul 2022	05:09 BST	21:24 BST
31 Jul 2022	05:24 BST	21:08 BST

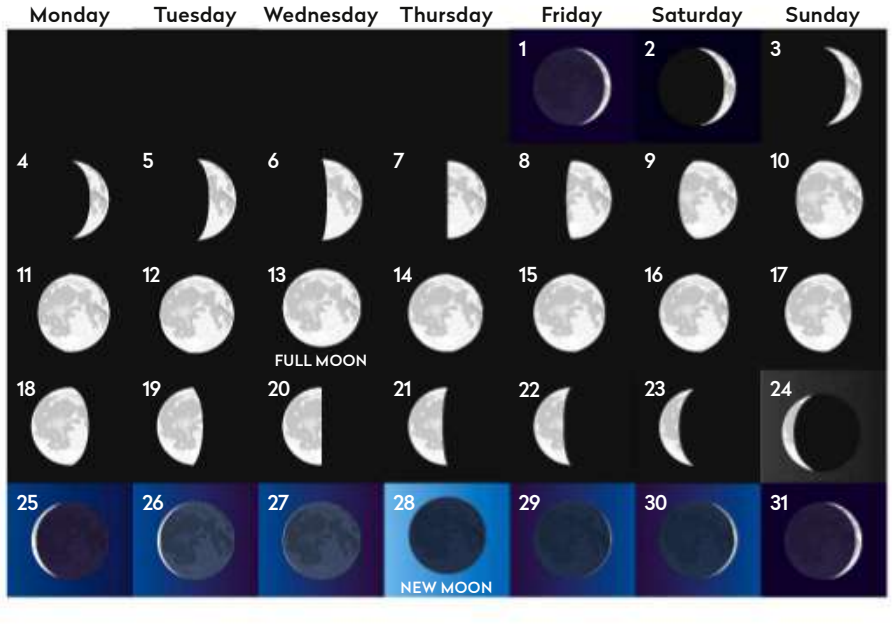
Moonrise in July*

Moonrise times

1 Jul 2022, 06:27 BST	17 Jul 2022, 23:46 BST
5 Jul 2022, 11:26 BST	21 Jul 2022, 00:32 BST
9 Jul 2022, 16:53 BST	25 Jul 2022, 01:40 BST
13 Jul 2022, 22:11 BST	29 Jul 2022, 05:29 BST

*Times correct for the centre of the UK

Lunar phases in July



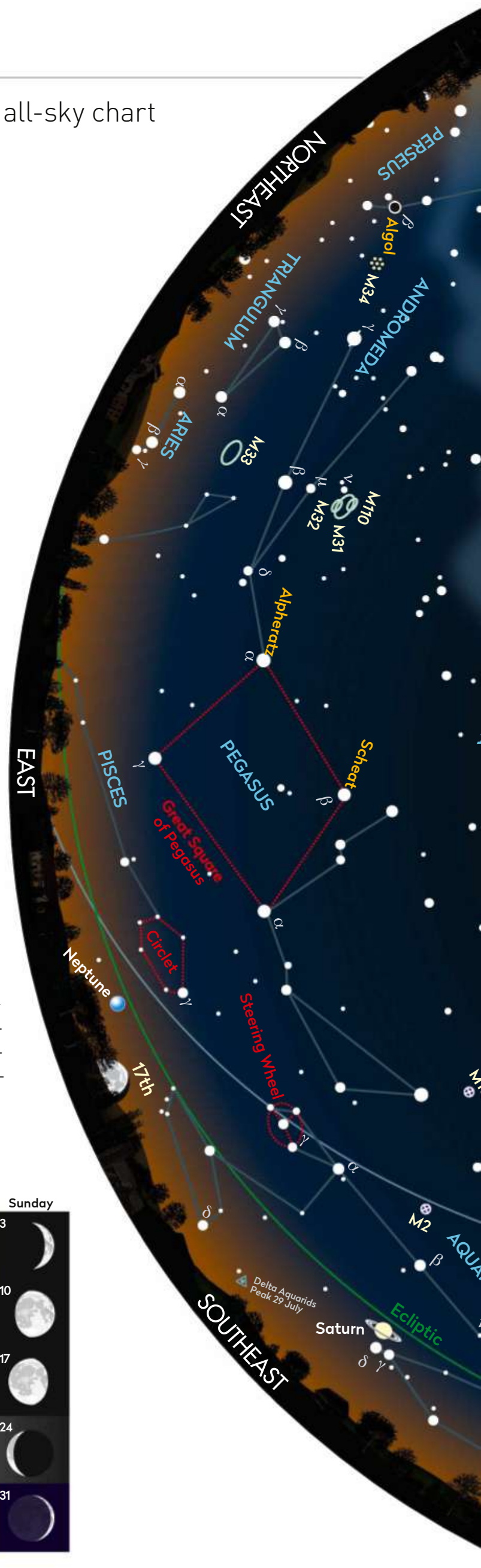
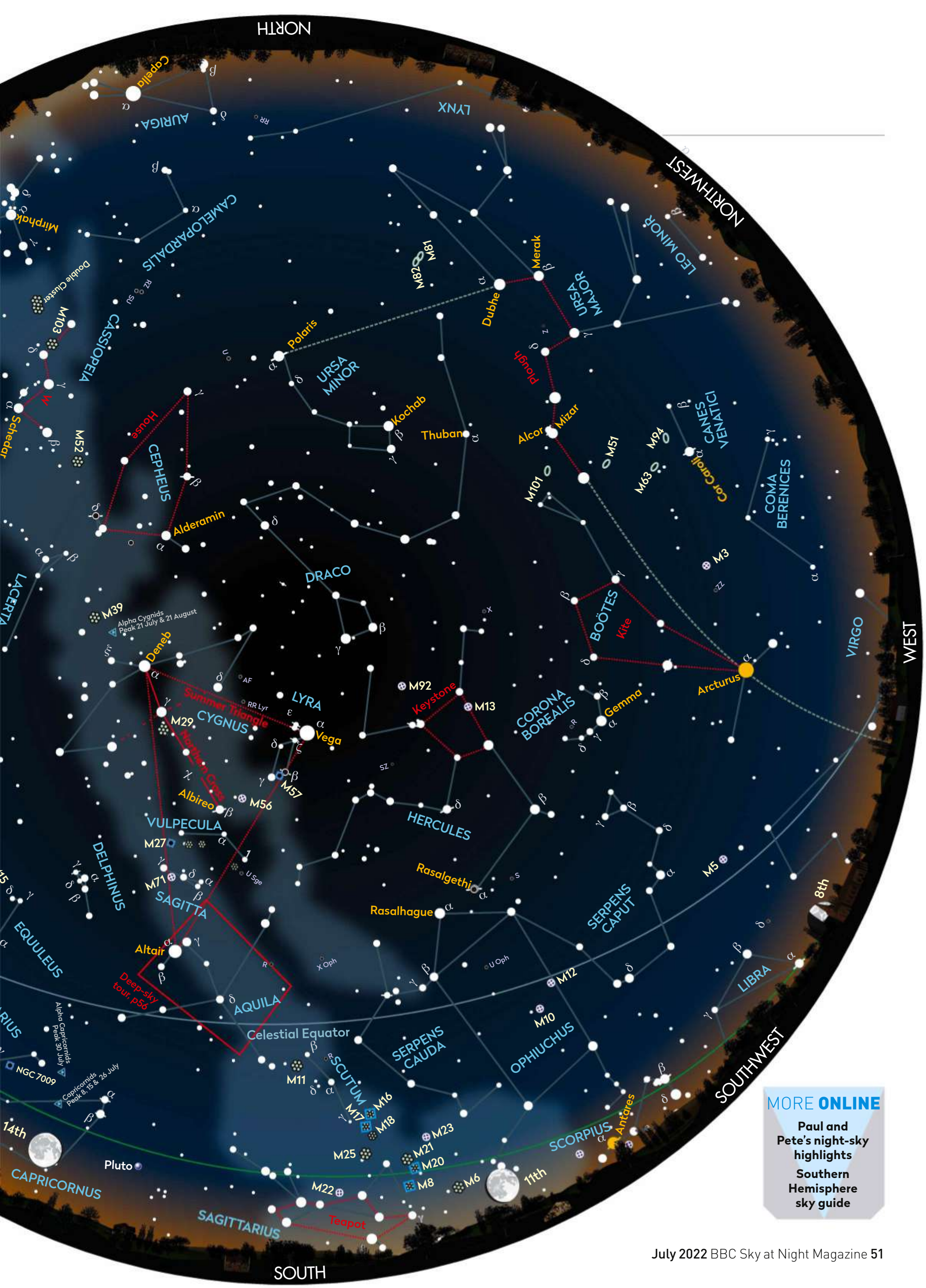


CHART: PETE LAWRENCE



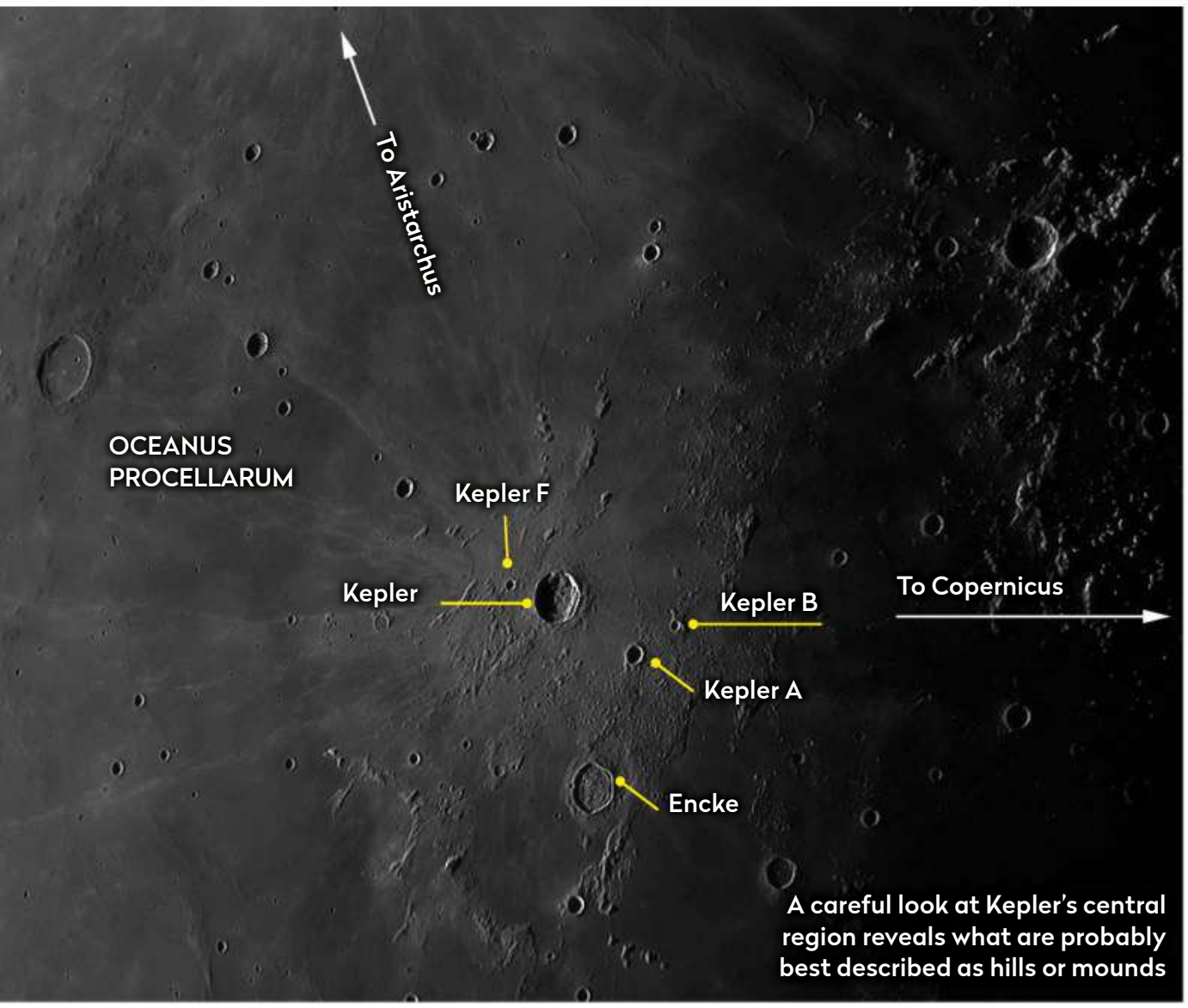
MORE **ONLINE**

Paul and Pete's night-sky highlights

Southern Hemisphere sky guide

MOONWATCH

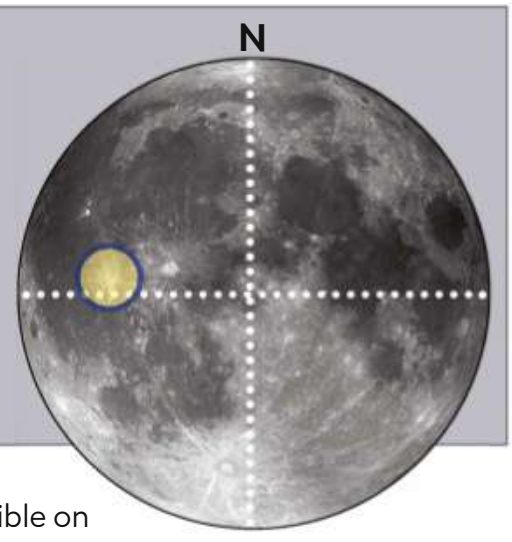
July's top lunar feature to observe



A careful look at Kepler's central region reveals what are probably best described as hills or mounds

Kepler

Type: Crater
Size: 31km
Longitude/Latitude: 38° W, 8.1° N
Age: Less than 1.1 billion years
Best time to see: Three days after first quarter (9–10 July) or two days after last quarter (23–24 July)
Minimum equipment: 50mm refractor



Kepler is one of the great ray craters visible on the Earth-facing side of the Moon. Although it's smaller than those other superb examples, 93km Copernicus and 86km Tycho, Kepler gets a visual boost due to its location within the dark lava of **Oceanus Procellarum**, a 700km x 500km basin occupying a good portion of the western half of the Moon's face we see from Earth.

Surrounded as it is by dark lava, the bright ejecta from Kepler stands out extremely well, radiating from the crater's sharply defined rim. Kepler's rim is impressive and rises to a peak height of 3,050m on the western side, the average crater depth being around 2,700m. Its sides appear to slope sharply down to a series of impressive, wide terraces. The overall appearance is not dissimilar to how an open-cast mine would look from above on the surface of Earth. The western rim slope has been measured to have an incline of 42°.

Does Kepler have a central mountain complex? Looking carefully at the region where the central mountains should appear reveals what are probably best described as central hills or mounds. Rising to a height of around 200m they aren't that impressive. To see them at their best, it's a good idea to choose a time when the lighting is oblique: the shadows they cast then gives them a good presence – perhaps more than they deserve.

The streaks that cross the areas surrounding Kepler are fascinating. Kepler makes up the the right angle corner in an approximate right-angled triangle formed with Copernicus, 540km to the east, and Aristarchus, 550km to the north-northwest, both ray craters in their own right and great features for comparison. Kepler's rays appear to stop abruptly at a north-south boundary to the east, but flow a great distance to the north and west, less so to the south. A long and well-defined example heads directly west of Kepler's rim, but it's noted that extending this back through Kepler and to the east will bring you directly to Copernicus. Is this ray purely from the Kepler impact or is it augmented by the ejecta rays that emanate from Copernicus? Possibly, but there are long examples of Kepler rays not in line with Copernicus as well.

Kepler's youthful age has allowed it to feature on the lunar surface unhindered with no incursions from other similar features. Its nearest neighbours are: 7km **Kepler F**, 32km to the west (centre-to-centre); the quintessentially bowl-shaped 11km **Kepler A**, which sits 65km to the southeast of Kepler; and 7km **Kepler B**, 81km to the east. The ancient, flat-floored form of 30km **Encke** is the largest nearby crater, located 115km to the south-southeast. Encke is an interesting crater to compare with Kepler. Its rim is irregular in shape but still sharp, despite an age estimated at more than 3.2 billion years. Its floor is fairly level but filled with concentric ridges and furrows.

The bright ejecta from Kepler stands out, radiating from the crater's rim

Although you'll get the most detail from Kepler at times of low Sun angle when the lighting is oblique, the bright nature of the crater's ejecta and relative darkness of the surrounding **Oceanus Procellarum** and Mare Insularum to the east, means that Kepler also stands out well during the direct illumination you get around full Moon.

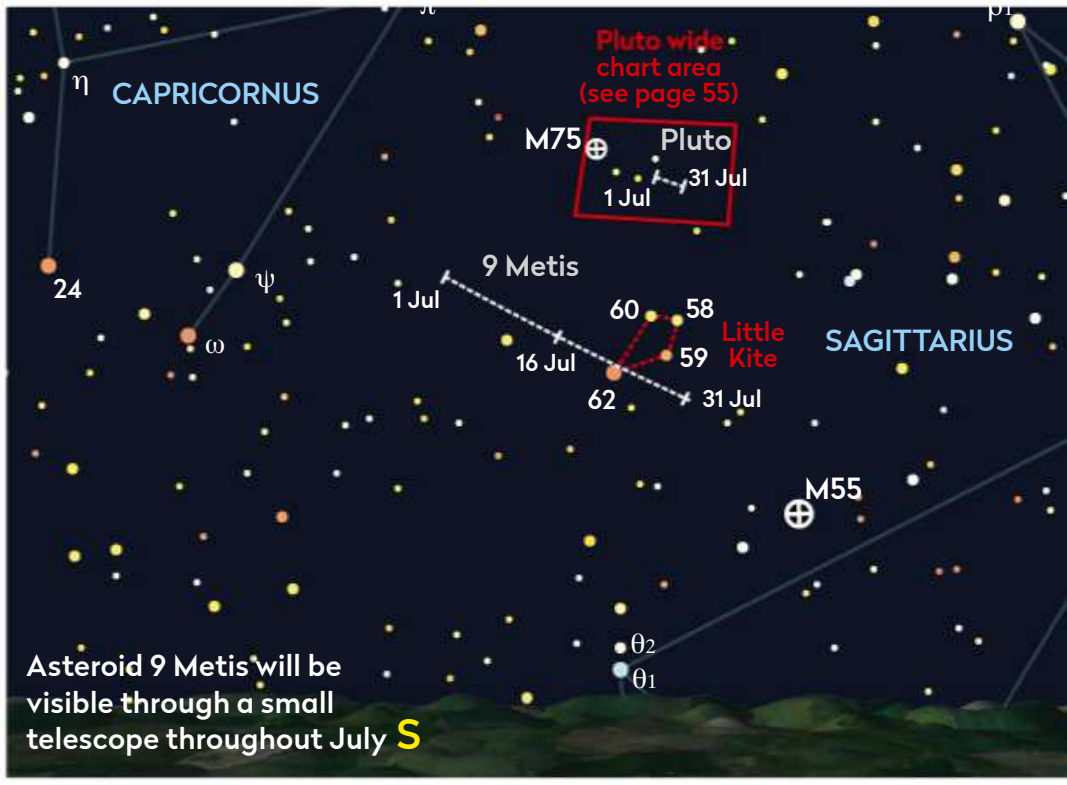
PETE LAWRENCE X 3

COMETS AND ASTEROIDS

Asteroid 9 Metis will brighten favourably over the course of the month

Asteroid 9 Metis reaches opposition on 20 July, having tracked from southern Capricornus at the month's start into Sagittarius. This area of sky can be challenging to navigate due to the fact that it never gets very high from the UK. The start of the track is also less easy to navigate to, thanks to a lack of notable stars in the southeast corner of Capricornus. The situation does improve throughout July though, thanks in part to darkening skies, but also by virtue of a small kite-shaped pattern – the Little Kite – formed by 58 Omega, 59, 60 and 62 Sagittarii. These stars range in brightness from mag. +4.5 to mag. +4.7 and thanks to the area being devoid of much else, do tend to stand out.

The asteroid begins the month at mag. +10.1, brightening towards opposition on the 20th, when it shines at mag. +9.7. By July's end it only dims by one tenth of a magnitude to end the month at mag. +9.8. This places 9 Metis within small telescope range. One caveat will be the Moon, which is full on 13 July, making it difficult to navigate this area of sky around mid-month. On the morning of the 14th, the Moon will sit immediately west of the kite-shaped asterism mentioned earlier. On opposition night, the Moon will appear 56%-lit, 80° to the east, and should be less intrusive, a situation that continues to improve towards July's end.



Metis is a main-belt asteroid, located in a vast band of similar objects orbiting between Mars and Jupiter. It is a large siliceous or S-type asteroid, a term used to describe a stony or mineralogical composition. The best-fit size of Metis is a tri-axial ellipsoid 222km x 195km x 140km. It was discovered by Irish astronomer Andrew Graham with a 3-inch, wide-field scope made for hunting comets.

STAR OF THE MONTH

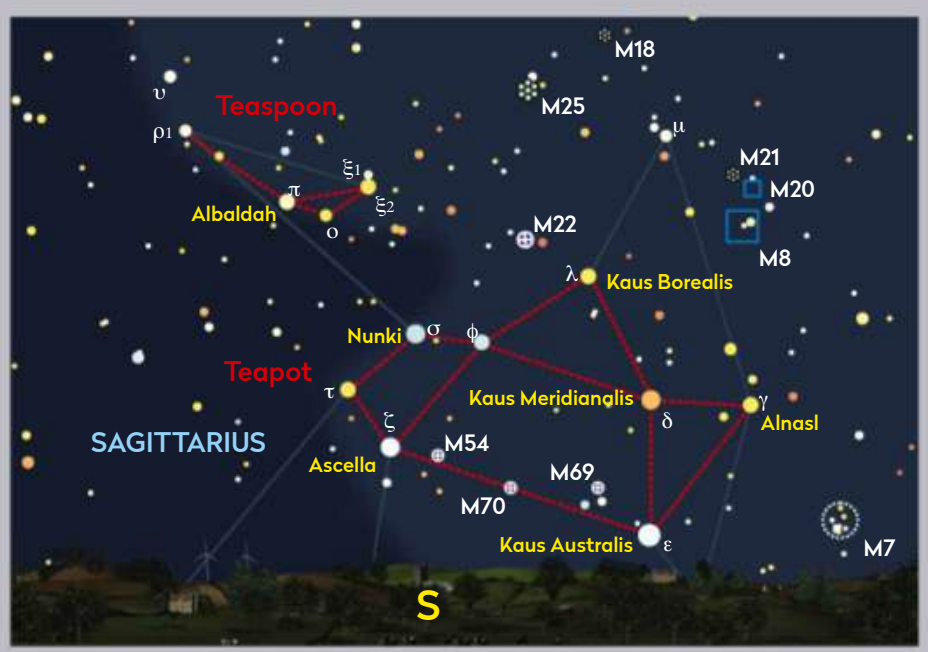
Kaus Meridionalis, a bow star of Sagittarius

The Teapot is a familiar asterism of the southern sky. From the UK, it never climbs to a significant altitude when it's at its highest point due south, so make sure you have a clear horizon in order to see it. It's formed from a group of stars within Sagittarius, and the star Delta (δ) Sagittarii marks the point where the lid, body and spout are joined. It had the traditional name Kaus Meridionalis, which refers more to the mythological interpretation of Sagittarius as a centaur archer than a teapot!

There are three stars in Sagittarius named Kaus; Kaus Borealis (Lambda (λ) Sagittarii), Kaus Meridionalis and Kaus Australis (Epsilon (ε) Sagittarii). The name Kaus means 'bow', the 'borealis', 'meridionalis' and 'australis' means northern, middle and southern. In mythology the three stars represent the top, middle and bottom of Sagittarius's bow.

The Bayer order in Sagittarius isn't logical, with Kaus Australis brightest at mag. +1.8, then Nunki (Sigma (σ) Sagittarii) at mag. +2.0 and Ascella (Zeta (ζ) Sagittarii) at mag. +2.6. Kaus Meridonalis shines at mag. +2.7 and for once is well labelled as the delta star, because it's the fourth brightest in Sagittarius. In case you're wondering, Rukbat (Alpha (α) Sagittarii) is mag. +3.9, but it's too far south to be seen from the UK.

▼ **The name Kaus Media was adopted for Kaus Meridionalis in 2016 by the Astronomical Union**

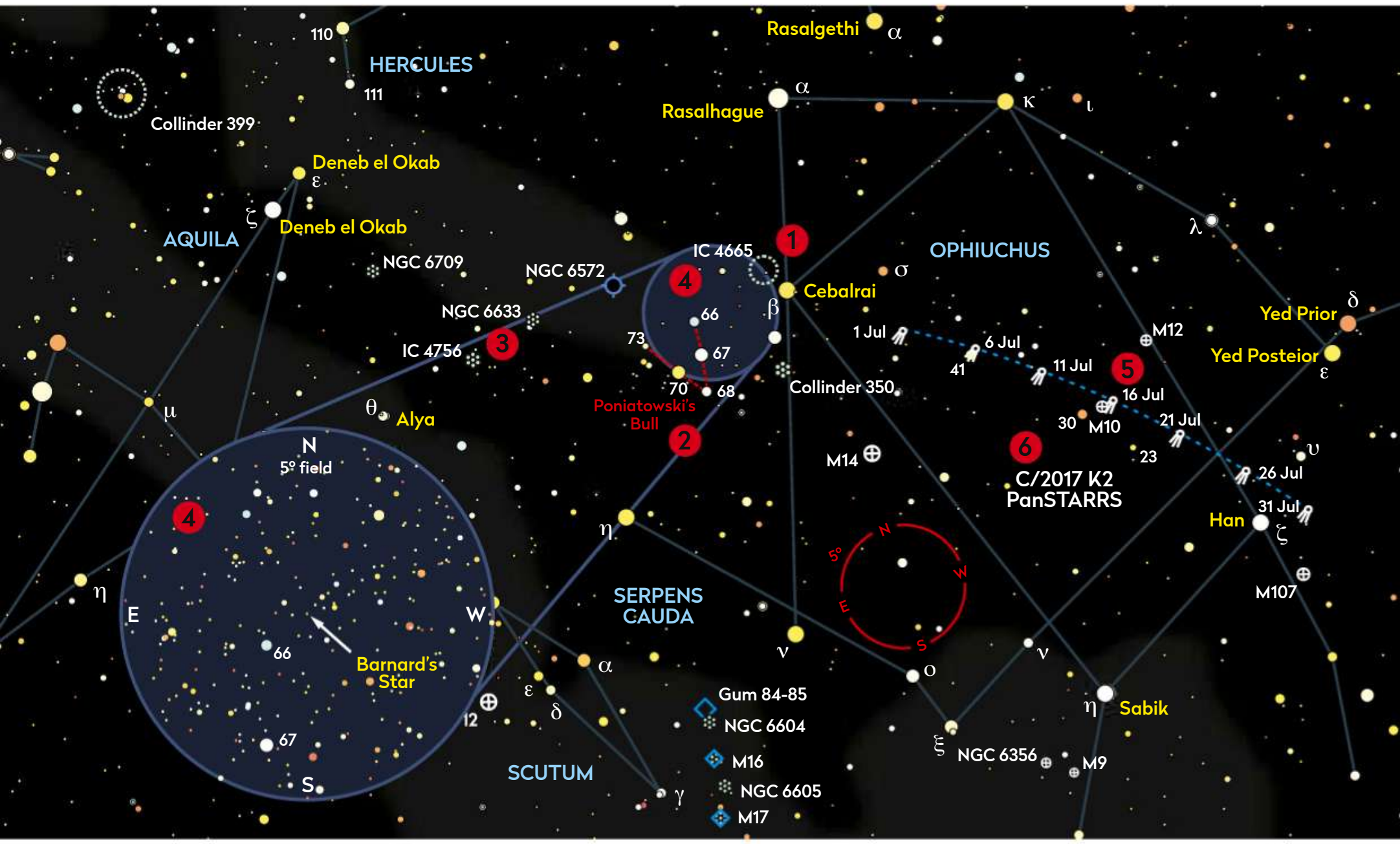


Kaus Meridionalis is an orange-giant star with a spectral type of K3 III and an estimated distance from the Sun of 348 lightyears. It's a binary system, the companion being a white dwarf. The primary is estimated to be 3.2 times more massive than the Sun with a diameter that's 16 times larger. It is estimated to be 260 million years old.

BINOCULAR TOUR

With Steve Tonkin

Our roundup of wide-field gems includes the Summer Beehive and Barnard's Star



1. The Summer Beehive

10x 50 The Summer Beehive (IC 4665), looks like a slightly smaller version of Praesepe (the Beehive Cluster) and, with its curved chain of white stars that form part of the letter 'H' in the inverted word 'HI', welcomes you to the summer skies. This relatively young cluster is a delight in binoculars of any size and you should easily be able to resolve 10 or more stars with a pair of 10x50s. ☐ **SEEN IT**

2. Poniatowski's Bull

10x 50 We'll continue with another easy object, one that looks better in wide-field binoculars than any other. Poniatowski's Bull (Melotte 186) is a 4° diameter open cluster that includes the V shape formed by 66, 67, 68, 70 and 73 Ophiuchi. These 4th and 5th magnitude stars make it similar to the Hyades cluster in Taurus, hence its common name, given to it in the 18th century in honour of Stanisław Poniatowski, King of Poland. ☐ **SEEN IT**

3. Graff's Cluster and NGC 6633

10x 50 Our next target is a pair of contrasting clusters. Follow the left-hand leg of the V-shaped asterism of Melotte 186 a further 5½° to the northeast to find NGC 6633, with its four brightest stars glinting against the 20-arcminute gleam of the unresolved stars. If you now pan 3° towards mag. +4.6 Alya (Theta (θ) Serpentis), you will find the 1° diameter glow of Graff's Cluster, IC 4756. ☐ **SEEN IT**

4. Barnard's Star

15x 70 This veritable 'Greyhound of the Skies' has the greatest proper motion (apparent motion relative to the celestial sphere). To find it, identify mag. +4.8 star 66 Ophiuchi, and use the inset chart, above. It only shines at mag. +9.5, so it can be a challenging target in summer skies that don't get properly dark. Using binoculars, it will take you about a decade to detect its apparent motion of 10.3 arcseconds a year. ☐ **SEEN IT**

5. M10 and M12

10x 50 M12 is close to the northeast apex of an equilateral triangle that has mag. +2.7 Yed Prior (Delta (δ) Ophiuchi) and Zeta (ζ) Ophiuchi as its other apexes; M10 is about 3° southeast of it. They offer a useful demonstration of averted vision: you will find that when you direct your gaze to one, the other brightens and grows. This also shows that M10 has a much more distinct core. ☐ **SEEN IT**

6. Comet C/2017 K2 (PanSTARRS)

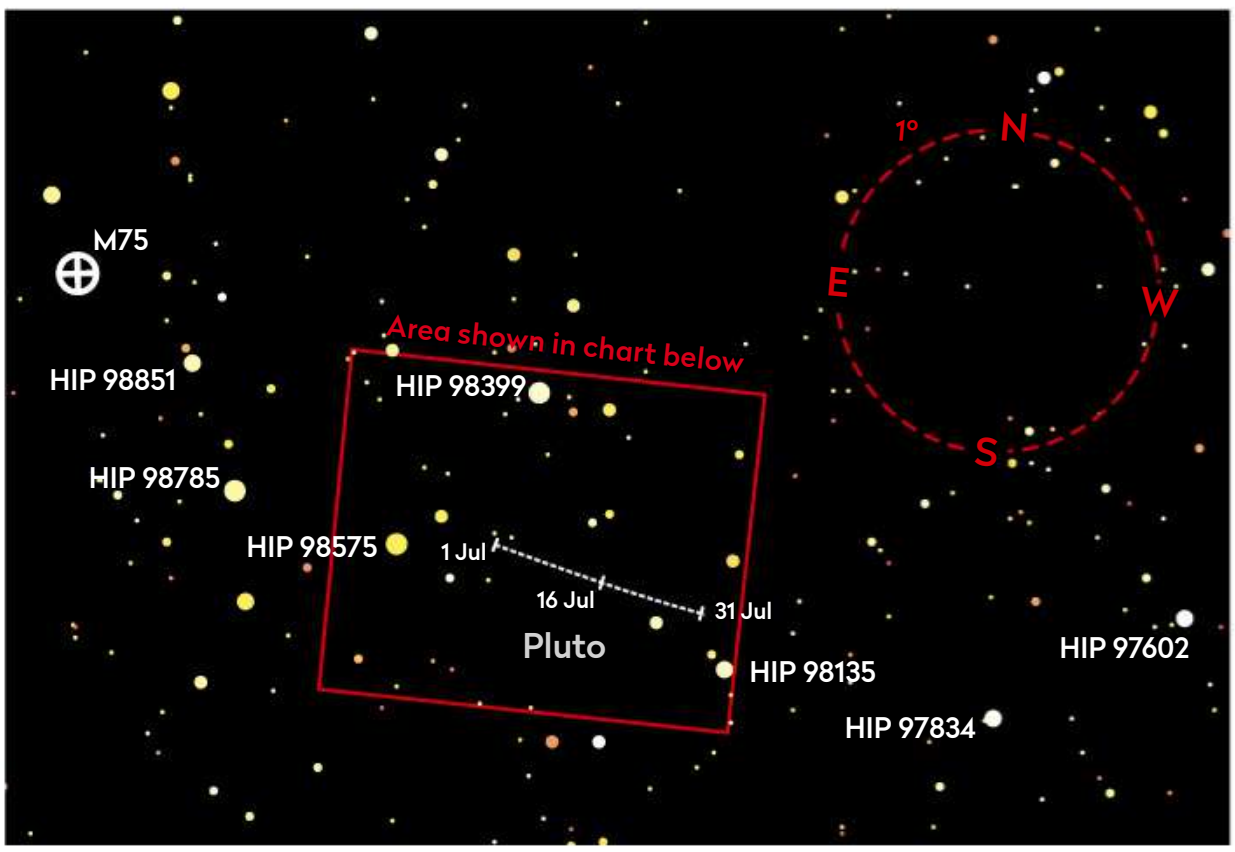
15x 70 Since its discovery five years ago, this comet has raised hopes of a good apparition as it approaches perihelion. During July, it is predicted to be within the grasp of small binoculars as it traverses Ophiuchus, passing M10 on the 15th. Although it brightens, it also moves southwards, so this could be the best time to observe it from UK latitudes. ☐ **SEEN IT**

☑ Tick the box when you've seen each one

PETE LAWRENCE X 3

THE SKY GUIDE CHALLENGE

Can you observe and capture the distant dwarf planet Pluto throughout the month?



▲ **Globular cluster M75 is a useful target for locating the star field where Pluto is found**

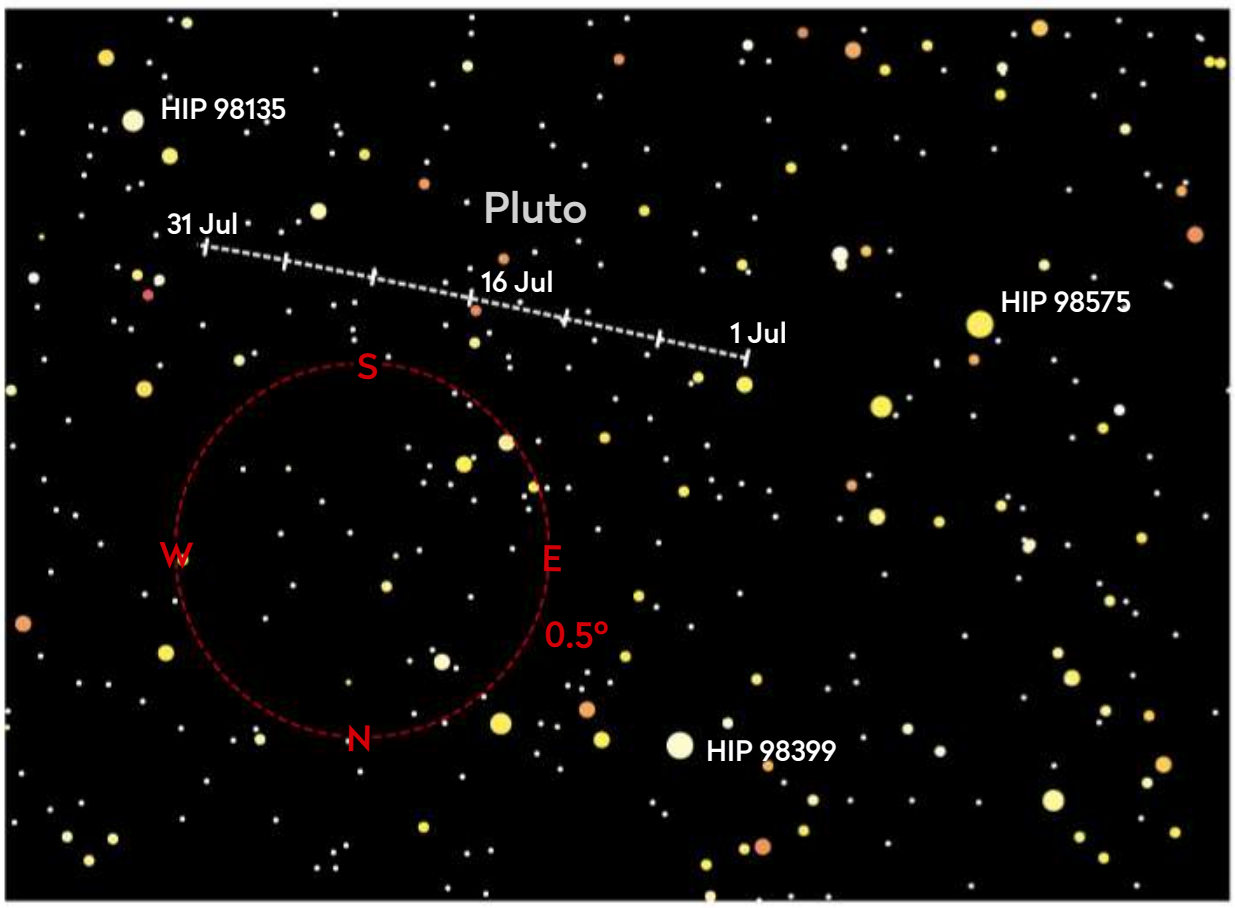
Dwarf planet Pluto reaches opposition on 20 July in Sagittarius, close to the border of Capricornus. The mag. +8.6 globular cluster M75 sits even closer to the border and is a nearby navigational guide (see chart, above). In July, Pluto moves westwards, starting 1.5° west-southwest of M75. Our challenge is to locate and capture this distant world, which appears like a 14th magnitude star in a telescope.

The best way to 'see' Pluto is to use the asteroid-tracking method of recording the suspected star field over the course of several nights, looking for the faint dot that appears to be moving. During July, Pluto's magnitude remains a steady +14.3. We'd normally recommend at least a 300mm scope for this, but additional aperture can only help as Pluto is quite low in the sky. There are claims that Pluto has been seen in smaller instruments than this under pristine skies.

The sure-fire way to record it is to photograph the star field where Pluto is expected to be located

The sure-fire way to record it is to photograph the star field where Pluto is expected to be located. Here, M75 works wonders as a starting guide. From M75 head half-a-degree to the southwest to locate mag. +7.5 HIP 98851. A fraction under half a degree south-southwest of this star lies mag. +6.4 HIP 98785, and half a degree to the west-southwest of this star is mag. +6.0 HIP 98575. Keep the line going from HIP 98785 through 98575 for approximately twice that distance again to arrive at mag. +7.6 HIP 98135. Pluto tracks parallel to the line between HIP 98575 and 98135, running slightly north of it. A minimum of a 200mm–300mm lens attached to a DSLR or MILC is recommended for this challenge; use a medium to high ISO. You'll need to aim to record stars slightly fainter than the faintest shown on our narrow-field chart (below) to succeed, so a tracking mount is recommended to allow you to extend the exposure time without star trails.

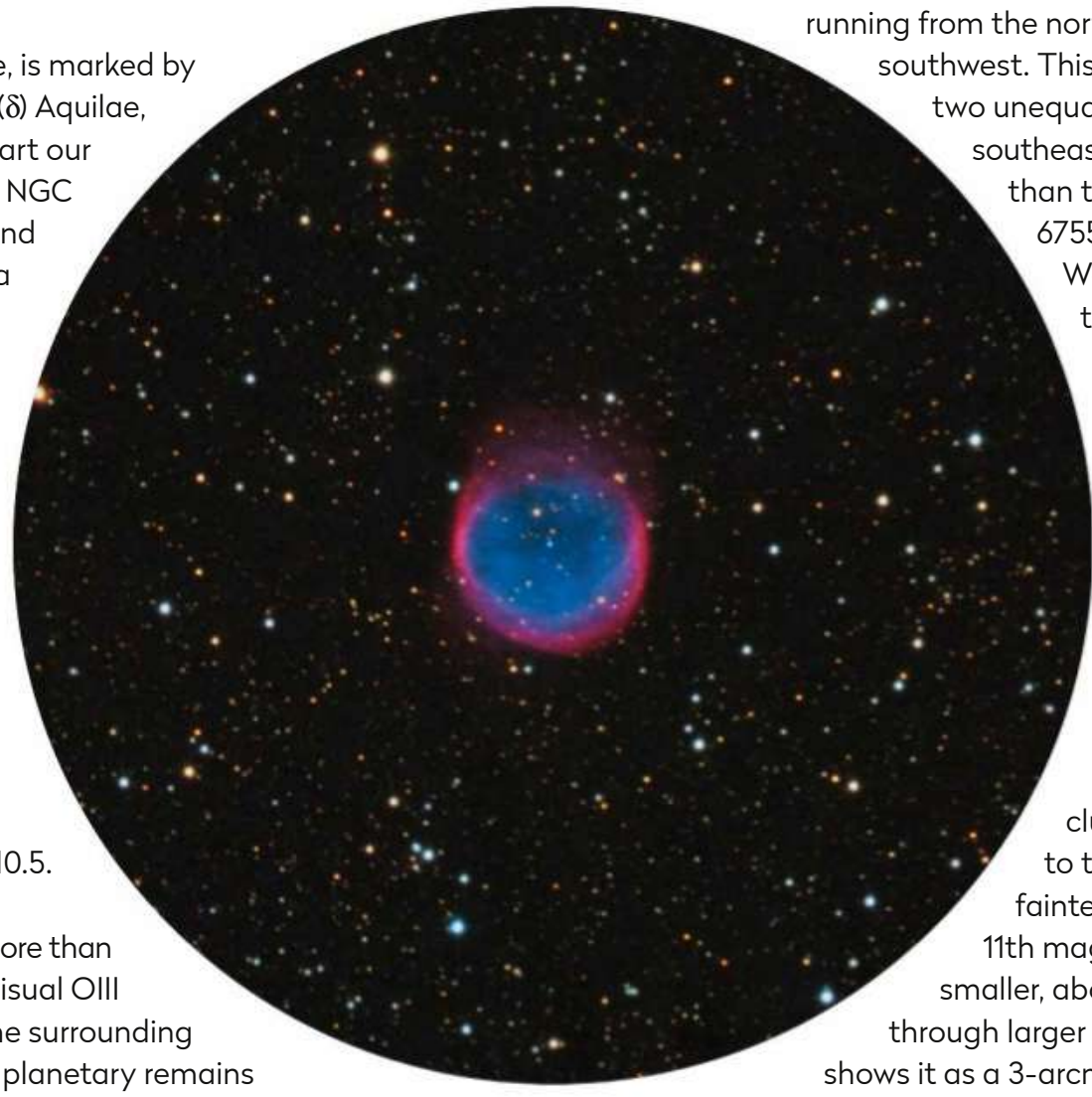
Record as many images as you can throughout the month, loading them into a layer-based editor one image per layer. Carefully align the stars between layers and flick between the frames to see if you can spot something faint moving in a straight line over the course of the month. If you can, that's likely to be Pluto. If you can, check your results using the first few images and increase camera sensitivity (higher ISO and/or longer exposures) if you can't see Pluto at all. Low altitude and haze will make the job more challenging, as will the presence of the Moon. The bright post-solstice skies at the start of July will also add an extra dimension of difficulty to this already tricky challenge.



▲ **Telescope view (south up) of the star field through which Pluto will be moving**

DEEP-SKY TOUR

This month we take in sights in the middle of the constellation of Aquila, the Eagle



▲ Use a 250mm telescope to reveal an off-centre dark patch in the planetary nebula NGC 6781

MICHAEL BREITE/ STEFAN HEUTZ/ WOLFGANG RIES/CCDGUIDE.COM, CHART BY PETE LAWRENCE

1 NGC 6790

Aquila, the Eagle, is marked by mag. +3.3 Delta (δ) Aquilae, which is a good place to start our tour. The planetary nebula NGC 6790 is located 1.6° south and 0.6° west of mag. +3.3 Delta (δ) Aquilae. It's tiny, with an apparent size of 4 x 3 arcseconds, which is similar to the apparent size of Uranus. At this size, the 19,000 lightyear-distant planetary won't show much detail, even through large scopes, but smaller planetaries tend to have a higher surface brightness. NGC 6790 is listed with an integrated magnitude of +10.5. Although in most amateur scopes it appears as little more than a blue/green fuzzy star, a visual OIII (Oxygen) filter will cause the surrounding field stars to dim while the planetary remains bright, an important planetary-hunting technique.

2 NGC 6760

Imagine Delta (δ) Aquilae as the 12 o'clock position on a clock face. Using NGC 6790 as the dim centre of the clock, at the 4 o'clock position lies mag. +5.1 HIP 94885. Our next tour target, globular cluster NGC 6760, lies 1.8° west of this star. Unlike NGC 6790, NGC 6760 has a good size to it, visually appearing around 6 arcminutes across through larger instruments. Its integrated magnitude is listed as mag. +9.1, so it's easy to find with smaller instruments too. The apparent size of deep-sky objects varies with the aperture of the scope they're being observed with. A 150mm telescope shows NGC 6760 as a two-arcminute object with a mottled texture at 150x magnification. A 250mm scope shows it larger, nearing four arcminutes across and with a well-defined core.

3 NGC 6755

Head 3.2° north-northwest of NGC 6760 and you'll be in the vicinity of our next target, open cluster NGC 6755. This is unusual because it appears to be divided by a dark region running from the northeast through to the southwest. This splits the cluster stars into two unequally bright regions, the southeastern one appearing brighter than the northwestern one. NGC 6755 is located within the Milky Way's boundary, but despite the multitude of background stars here, it still manages to stand out well. Shining with an integrated magnitude of +7.5, the cluster covers an area roughly half the apparent size of the Moon.

4 NGC 6756

NGC 6756 is another open cluster, located half a degree to the north of NGC 6755. It's fainter than NGC 6755, listed at 11th magnitude. It also appears smaller, about 4 arcminutes across through larger scopes. A 150mm scope shows it as a 3-arcminute diameter faintly glowing patch. At 150x power, almost a dozen resolved stars can be seen. It appears as two halves due to the uneven distribution of brighter stars.

5 NGC 6781

Planetary nebula NGC 6781 lies 3° northeast of NGC 6756. Unlike our first target, NGC 6781 has an appreciable apparent size of 1.7 arcminutes, although shining with an integrated magnitude of +11.4, its surface brightness is reduced. Despite this, a 150mm scope shows its large circular glow easily. Use a magnification over 100x for the best view. A 250mm instrument reveals asymmetry in the disc brightness, the region to the south being brightest. A dark patch which appears off-centre may also be seen, displaced to the north.

6 NGC 6803

NGC 6803 is a challenging target, 4.7° to the northeast of NGC 6781, and 4° and a fraction south of Tarazed (Gamma (γ) Aquilae). Listed at mag. +11.4, it's tiny at 5 arcseconds, and a little larger than the apparent size of Mars when furthest from Earth. The nebula's tiny apparent diameter makes it hard to discern from the surrounding stars. A mag. +13.2 star sits to the north-northwest of NGC 6803's tiny disc, which also helps to disguise the object. Here, the OIII blink technique mentioned for Item 1 works well. Select a mid– to high power eyepiece and move the filter between your eye and the ocular. If the OIII filter dims everything too much, try a UHC filter.

This Deep-Sky Tour has been automated
ASCOM-enabled Go-To mounts can now take you to this month's targets at the touch of a button, with our Deep-Sky Tour file for the EQTOUR app. Find it online.

More **ONLINE**

Print out this chart and take an automated Go-To tour. See page 5 for instructions.

Vyssotsky 2-2
6
NGC 6803
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NGC 6804
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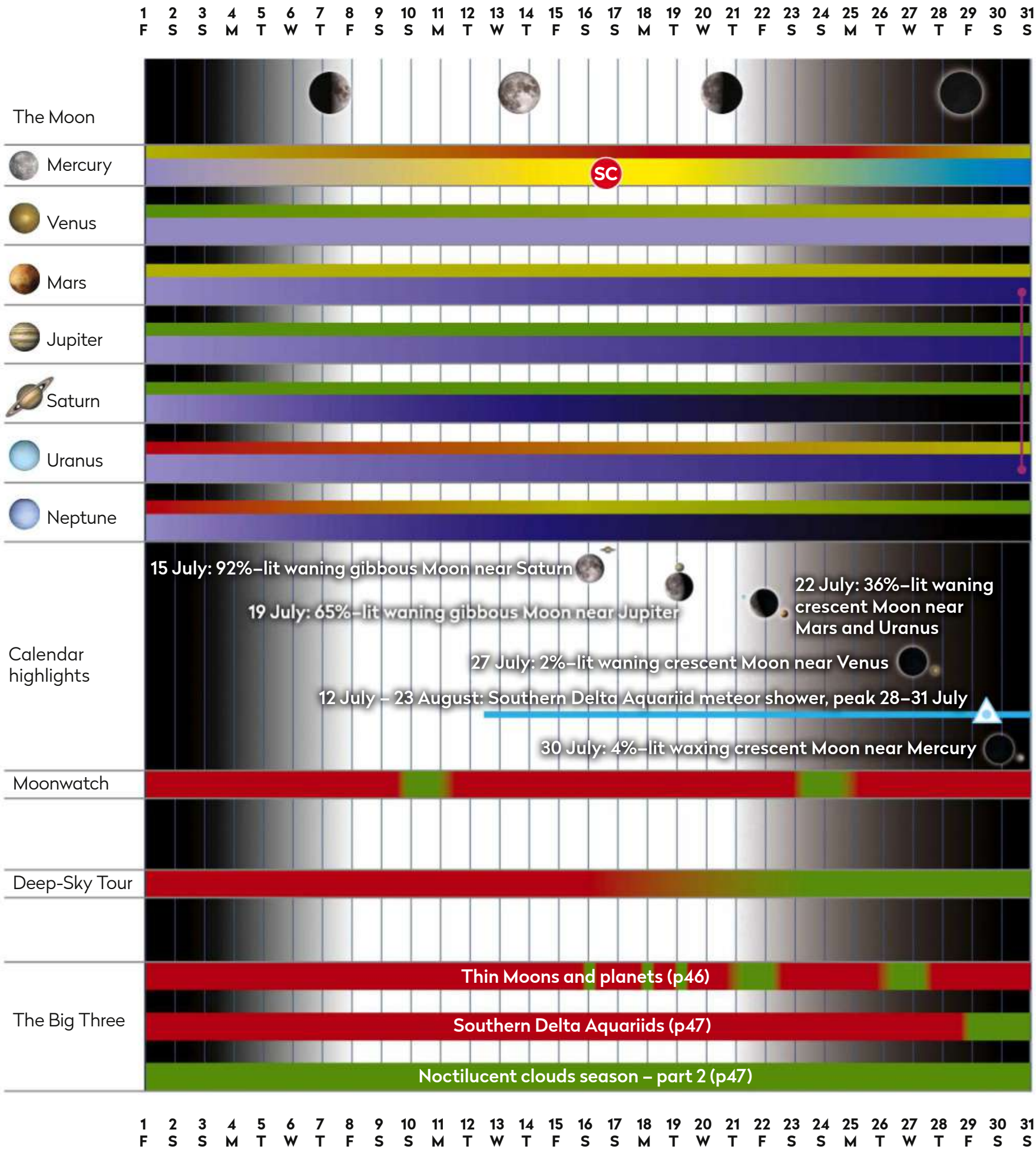
AT A GLANCE

How the Sky Guide events will appear in July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The Moon
Mercury
SC
Venus
Mars
Jupiter
Saturn
Uranus
Neptune
Calendar highlights
15 July: 92%–lit waning gibbous Moon near Saturn
19 July: 65%–lit waning gibbous Moon near Jupiter
22 July: 36%–lit waning crescent Moon near Mars and Uranus
27 July: 2%–lit waning crescent Moon near Venus
12 July – 23 August: Southern Delta Aquariid meteor shower, peak 28–31 July
30 July: 4%–lit waxing crescent Moon near Mercury
Moonwatch
Deep-Sky Tour
The Big Three
Thin Moons and planets (p46)
Southern Delta Aquariids (p47)
Noctilucent clouds season – part 2 (p47)

KEY

Observability

Optimal | Poor

Best viewed

Morning twilight | Daytime | Evening twilight | Night

Sky brightness during lunar phases

Dark (first quarter) | Light (full Moon) | Dark (last quarter) | Total darkness (new Moon)

- IC Inferior conjunction (Mercury & Venus only)
- SC Superior conjunction
- OP Planet at opposition
- Meteor radiant peak
- Planets in conjunction
- Full Moon
- First quarter
- Last quarter
- New Moon

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Close up on THE SUN

Together, Solar Orbiter and the Parker Solar Probe are giving us our closest ever look at the Sun. With both now in their science phases, **Ezzy Pearson** updates us on what we've already learned and what's still to come

SOLAR ORBITER: ESA/ATG MEDIALAB; PARKER SOLAR PROBE: NASA/JOHNS HOPKINS APL

Solar Orbiter (left) and the Parker Solar Probe (right) in orbit around our Sun

Although the star at the heart of our Solar System outshines everything else, its very brightness defies attempts to better understand it. Its light blinds any who look at it, while its heat scorches craft that venture too close. Despite this, specialised observatories have allowed solar astronomers to look on from afar over the years.

But now there are two telescopes giving an up-close view of the Sun. On 26 March, the European Space Agency's Solar Orbiter probe sailed past the Sun on its closest approach yet, coming within a third of the Earth-Sun distance to our star. And last year, its observing cousin, NASA's Parker Solar Probe, passed so near to the Sun that it flew through the outer layers of its atmosphere, sniffing out the pristine particles near the solar surface. But despite the pair being closer to the Sun than any other mission, they are looking at the star in two very different ways.

Big plasma bubble

"Solar Orbiter is a mission to explore the Sun and the surrounding heliosphere – the big plasma bubble that the solar wind blows into the interstellar medium," says Daniel Müller, project scientist for Solar Orbiter at the European Space Agency. "The driving rationale for Solar Orbiter is to establish the connections between what our home star does in terms of activity and how that manifests itself in the surrounding heliosphere, including the near-Earth environment. We combine measurements of the plasma ▸

ILLUSTRATION

ESA & NASA/SOLAR ORBITER/EUI TEAM; DATA PROCESSING: E. KRAAIKAMP (ROB), NASA, ESA/ATG MEDIALAB

▲ **Solar Orbiter's enormous 83-megapixel image of the Sun can be experienced online at bit.ly/ZoomIntoSun**

► at the location of the spacecraft with images of the Sun."

The mission launched on 10 February 2020, and has spent the last two years looping around our star. It spends much of its orbit at a distance to protect itself from the searingheat, only swooping in every five to six months for a close pass known as perihelion. Using flybys of Earth and Venus to pull its orbit close to the Sun, it now passes just 48.3 million km from our star.

Solar Orbiter has 10 scientific instruments, four of which look directly at the Sun. On 7 March, while at a distance of 75 million km, the spacecraft used them to take the closest ever image of the Sun. It was so close the camera couldn't fit the whole solar disc in frame, and instead had to take a mosaic of 25 images. In doing so it created a shot 10 times larger than what can be displayed on a 4K TV screen.

The other six instruments are in-situ experiments, measuring the environment in Solar Orbiter's location. One particular area the mission is paying attention to is the solar wind, sniffing out the gusts of charged particles as they stream out of the Sun.

"The solar wind is largely hydrogen and helium, but there's a sprinkling of other elements, and it's those that help us make the connection between the solar wind and where it came from," says Müller. "We identify where ions like oxygen and iron are on the Sun, then sniff them in the solar wind. We combine the measurements with the pictures and connect the two, linking what is flying past the spacecraft with what erupted on the Sun a day or two earlier."

Although the spacecraft's mission, and when it will be close to the Sun, are planned well in advance, during those passes it will adjust its focus to whichever area of the Sun is currently active.

"In March, we had interesting periods where there were major flares," says Müller. "The question was, can we point to where the flares just were, as there is a high likelihood that it will flare again. Hopefully the Sun will collaborate."

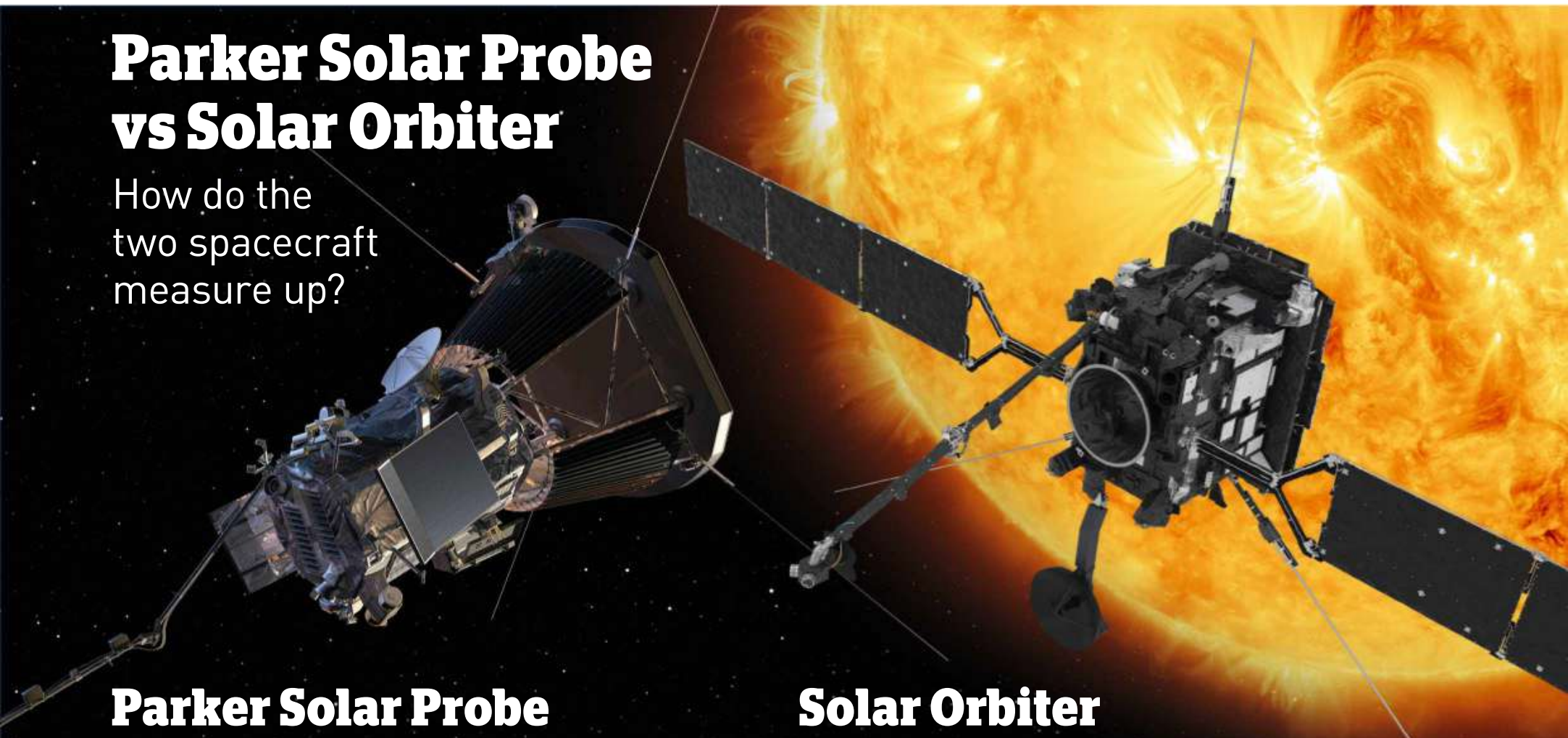
Flight to the poles

It will be a while until we find out if the Sun was working with the Solar Orbiter team, however, as the flyby generated so much data it only finished downloading in May, and is still being processed.

The spacecraft will continue looping around the Sun, using further encounters with Venus to shift

Parker Solar Probe vs Solar Orbiter

How do the two spacecraft measure up?

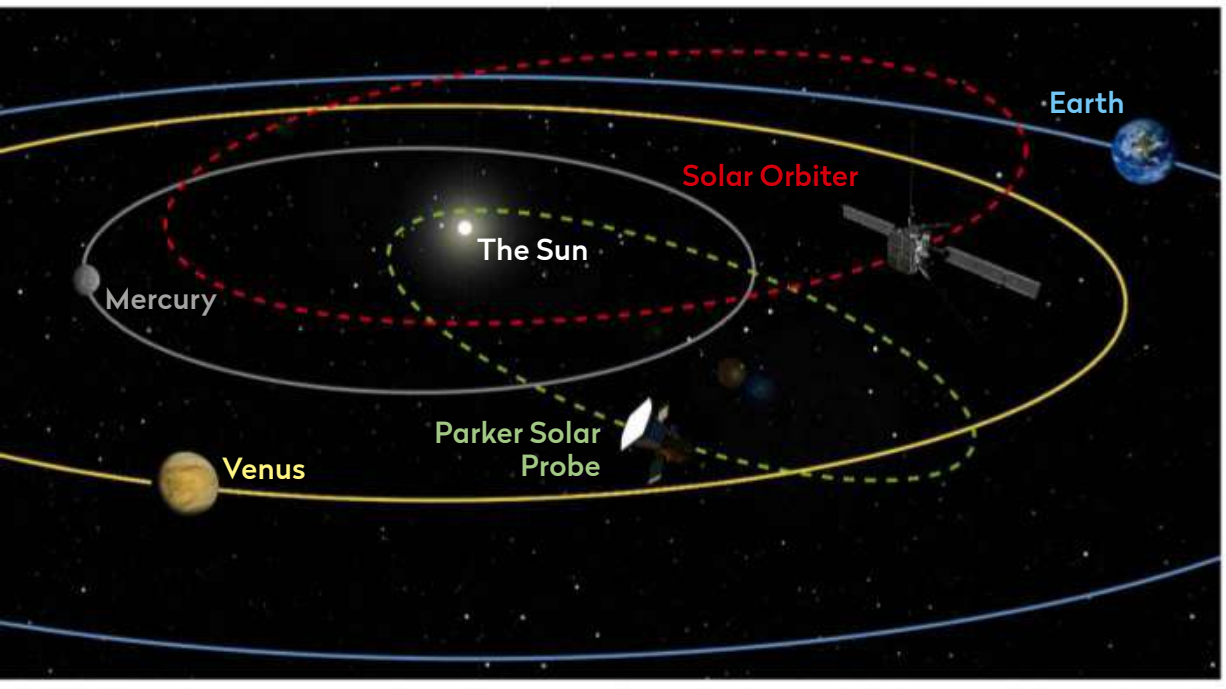


Parker Solar Probe

Closest pass to the Sun: 6.2 million km
Launch date: 12 August 2018
Mass: 685kg
In situ instruments: 3
Remote instruments: 1
Science goals: Investigate the Sun's corona and solar wind
Temperature: Heat shield can withstand direct heat of 2,500°C
Orbit: Highly eccentric orbit which takes it out to the orbit of Venus between perihelions

Solar Orbiter

Closest pass to the Sun: 42 million km
Launch date: 10 February 2020
Mass: 1,800kg
In situ instruments: 4
Remote instruments: 6
Science goals: Investigate solar polar regions and sunspot cycle
Temperature: 500°C
Orbit: With gravitational assists from Venus, the probe will rise up 33° above plane of the Solar System



▲ **Solar Orbiter and Parker's orbits are eccentric, making use of Venus's gravity to shift into new positions**

its orbit so that it eventually gets to within 0.28 AU (about 42 million km) of the Sun's surface. It won't be resting there for long though, as the spacecraft will then enter into a new science phase as it tips its orbit out of the ecliptic, allowing it to get a clearer view of the Sun's poles – something no other spacecraft has ever attained before.

The first polar pass is due on March 2025, at an angle of 17° to the ecliptic, but by July 2029, it should be at 33°. The hope is that this unique view of the Sun will give a greater insight into the solar cycle, the repeating pattern of activity in which the number of sunspots peaks and then lulls, only to peak once more 11 years after the last maximum. Though the pattern has been recorded for over 400 years, no one knows its cause.

"It's not clear why it has this periodicity of 11 years – other stars have different periods," says Müller. "There are various theories, but we can only validate them by getting data from the polar regions – you need a study from high over the poles to see how the magnetic field changes and gets transported. That's the next big milestone."

Solar Orbiter isn't the only mission getting cosy with the Sun, however, as NASA's Parker Solar Probe is also diving around the Sun. And if Solar Orbiter gets close to the Sun, then Parker brushes right past it. Just a month before Solar Orbiter's closest approach, Parker made its 11th perihelion journey, coming just 5.3 million km from the Sun's photosphere – the Sun's 'surface' layer, which emits the light we can see. This is so close that it actually passes through the outer layer of the Sun's atmosphere, the corona.

"Parker essentially takes a deep breath and flies into the Sun, hopefully coming out in one piece ▸

The many eyes observing the Sun

A few of the dozens of other solar observatories helping to put the pair's observations in context

Hinode, Japan

An Earth-orbiting satellite built in collaboration with the UK and USA, Hinode launched in 2006. Its goal is to understand the link between magnetic fields near the solar surface and the structure of the outer solar atmosphere, as well as understanding the 11-year solar cycle.

Daniel K Inouye Solar Telescope (DKIST), USA

With a 4m mirror, DKIST in Hawai'i is the largest solar telescope in the world. Its primary goal is to understand the solar dynamo, and it does so by taking high resolution images – capable of resolving magnetic features 35km in size – multiple times a second.

Solar and Heliospheric Observatory (SOHO), ESA

SOHO launched in 1995, with the aim of observing the Sun's outer layers including the chromosphere and corona. It helps give global context to measurements taken by probes closer in. It orbits the Sun 1.5 million km from Earth, at the L1 gravitational point.

Solar Dynamics Observatory (SDO), NASA

Along with Parker, SDO is part of NASA's Living With a Star programme, which aims to understand the Sun's influence on Earth and the space around it. Since 2010, the observatory has been taking images of the Sun in 10 wavelengths every 10 seconds.

▸ to downlink the data," says Müller. On 28 April 2021 at a distance of 18.8 solar radii (13 million km), Parker measured that it had passed the Alfvén critical surface – the point at which solar particles escape the Sun's magnetic field and become part of the solar wind. This was the first time Parker had 'touched the Sun' and entered the corona. With every pass after, Parker flies through the corona, and can measure the particles and magnetic fields closest to the Sun.

The goal of these deep dives is to understand the connection between the corona and the solar wind. However, getting so close means Parker has to withstand the Sun's intense heat and light. While its carbon-composite heat shield keeps its instruments at room temperature, it can't do anything about the brightness.

"It can't look at the Sun directly," says Müller. "It only has a camera pointing sideways, where it can look without burning."

Photos of the wind

The camera in question is the Wide-field Imager for Parker Solar Probe (WISPR), which photographs the solar wind as it blows past. These images show the patterns of bright particles known as streamers flowing throughout the corona, and helps to build a picture of what the wind looks like from within. The extreme orbit also means that Parker can carry just three other instruments to measure the particles and magnetic field around it. But even with its limited arsenal, Parker has managed to make some intriguing discoveries.

In 2019, when it was still 34 solar radii out, Parker observed strange zig-zag paths of charged particles known as switchbacks.

"The switchbacks are a reversal of the magnetic field," says Nour Raouafi, Parker's project scientist.

▼ Switchbacks, rapid flips in the Sun's magnetic field, were discovered by the Parker Solar Probe

NSO/NSF/AURA, NASA X 3, NASA'S GODDARD SPACE FLIGHT CENTER/CONCEPTUAL IMAGE LAB/ADRIANA MANRIQUE GUTIERREZ, NASA/JOHNS HOPKINS APL/NAVAL RESEARCH LABORATORY X 2, SOHO (ESA & NASA)

▲ **Parker provided the first close-up views of solar streamers, jets of bright particles within the corona**

"While our star's surface is 5,500°C, the corona reaches around one million degrees C, and no one knows why"

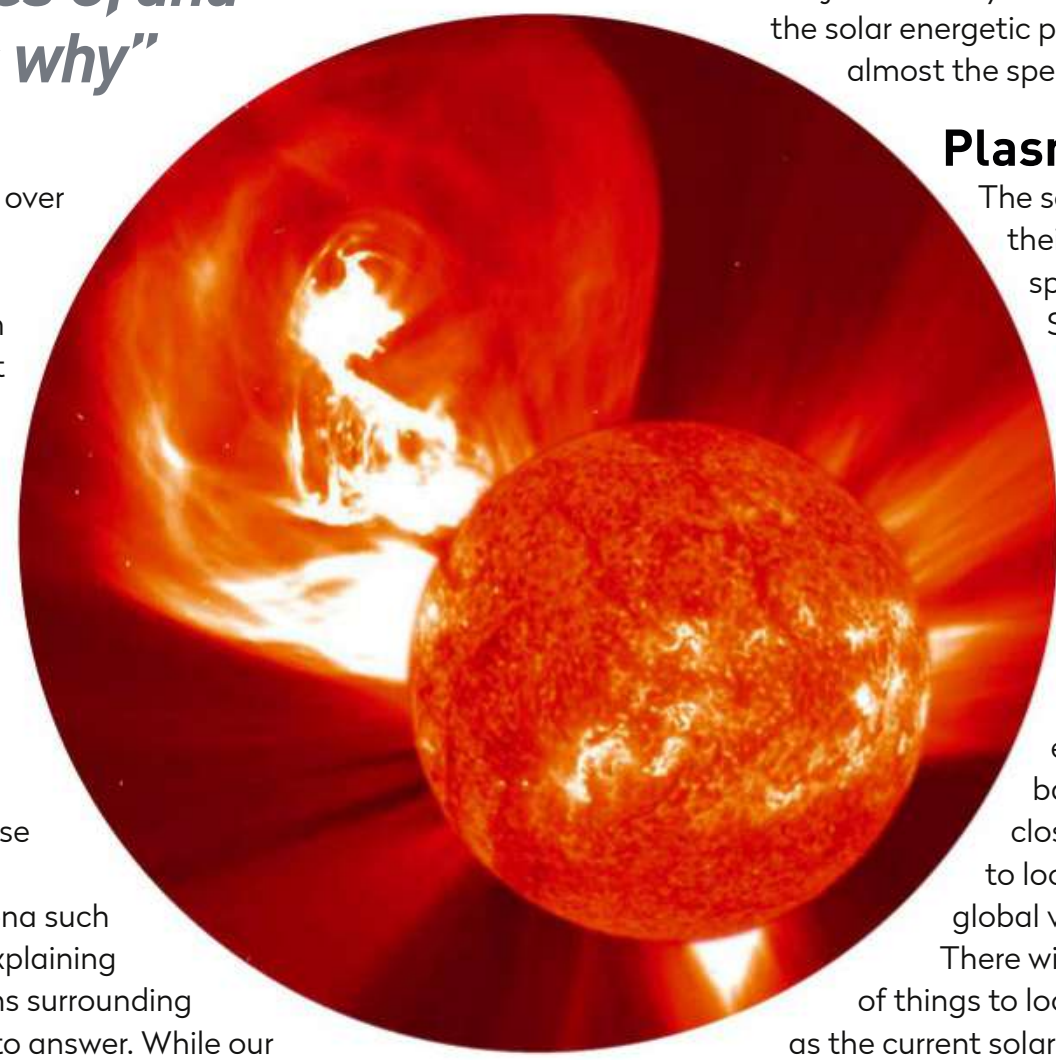
"The magnetic field will flip over itself in and out in a matter of seconds or minutes." Switchbacks were first seen by ESA's Ulysses spacecraft in the 1990s, but now that Parker has observed them much closer in to the Sun, it has discovered they are far more common than it first appeared. Parker was able to measure that these switchbacks are rich in helium, which can be traced back to magnetic funnels at the base of the corona.

Understanding phenomena such as switchbacks is vital to explaining one of the biggest questions surrounding the Sun that Parker hopes to answer. While our star's surface is measured at a balmy 5,500° C, the corona reaches temperatures of around one million degrees C and no one knows why. One theory is that jets of fast particles, like those seen in switchbacks, could be responsible.

"There are a variety of theories," says Kelly Korreck, NASA's Heliophysics programme scientist. "As we get more and more data to test those theories, we get closer to figuring out switchbacks and their role in the solar wind."

Just like Solar Orbiter, Parker is still closing in on its final orbit, with two more flybys of Venus planned to help bring in its orbit so that by December 2024, it will be flying 6.2 million km from the Sun at speeds of 690,000 km per hour. But the most exciting part of its mission will come at a time that no one will be able to predict.

"One thing we're looking forward to is when Parker Solar Probe flies through one of the huge coronal mass ejections very close to the Sun, and tells us how the solar energetic particles are accelerated to almost the speed of light," says Raouafi.



▲ **A coronal mass ejection caught by the SOHO spacecraft. The Parker Solar Probe will attempt to fly through one of these to study its acceleration**

Plasma sniffer

The solar probes will continue their science phases as they spiral closer towards the Sun, and their return will only grow as they can now collaborate together. While Parker takes a direct look at what is happening close to its surface, sniffing the solar wind and plasma, Solar Orbiter can take a wider look at what is going on. At the same time, the existing solar observatories based on the ground and closer to Earth orbit will be able to look at the whole Sun, giving a global view.

There will certainly be no shortage of things to look at in the coming years, as the current solar cycle is expected to reach its maximum between November 2024 and March 2026. With a growing number of sunspots, flares and coronal mass ejections creating a storm of space weather, all of the world's solar observers will be watching with interest, trying to discover what makes the solar winds blow.

Dr Ezzy Pearson is *BBC Sky at Night Magazine*'s news editor. Her book *Robots in Space* is available through History Press

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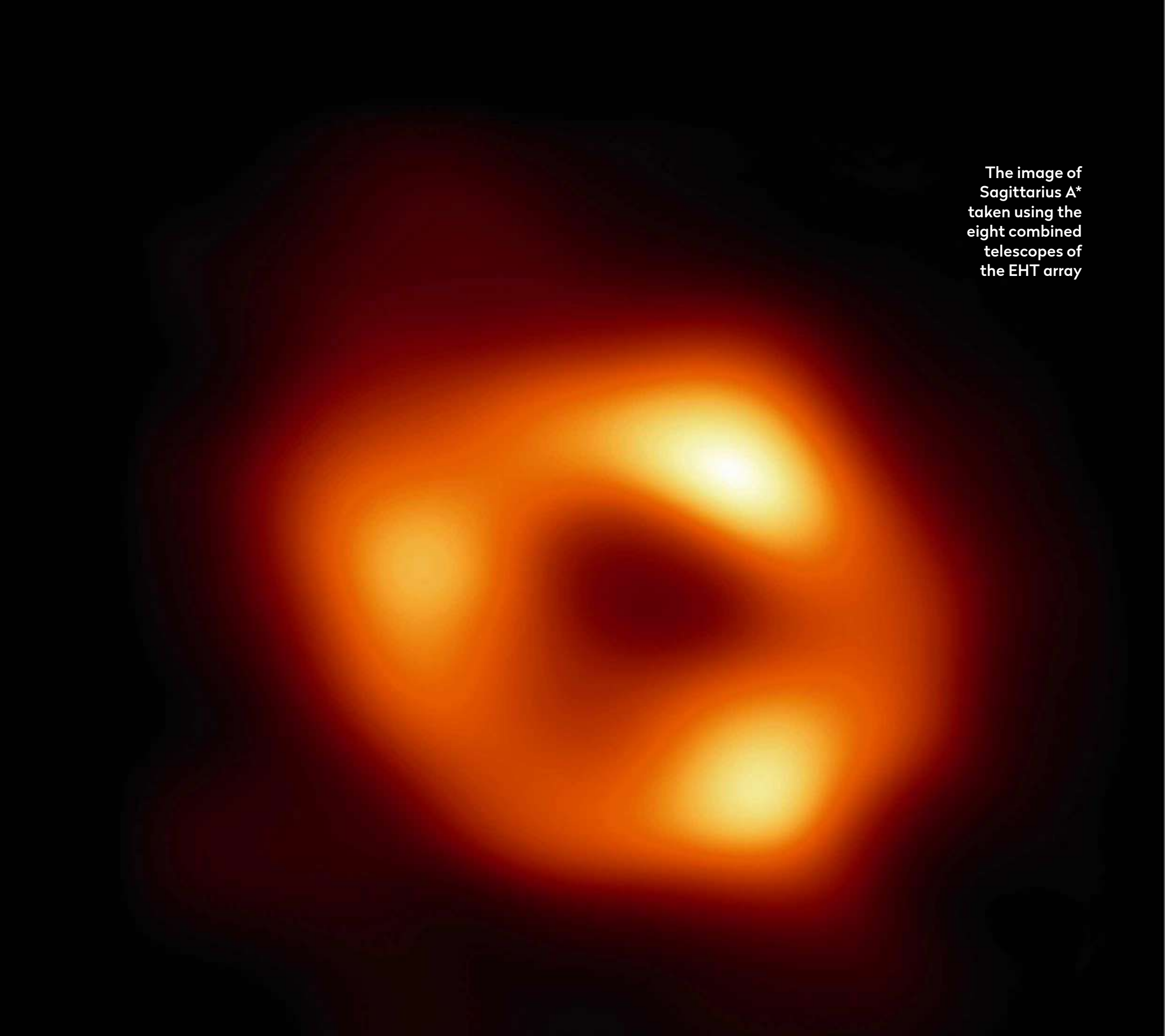


The image of Sagittarius A* taken using the eight combined telescopes of the EHT array

EHT COLLABORATION

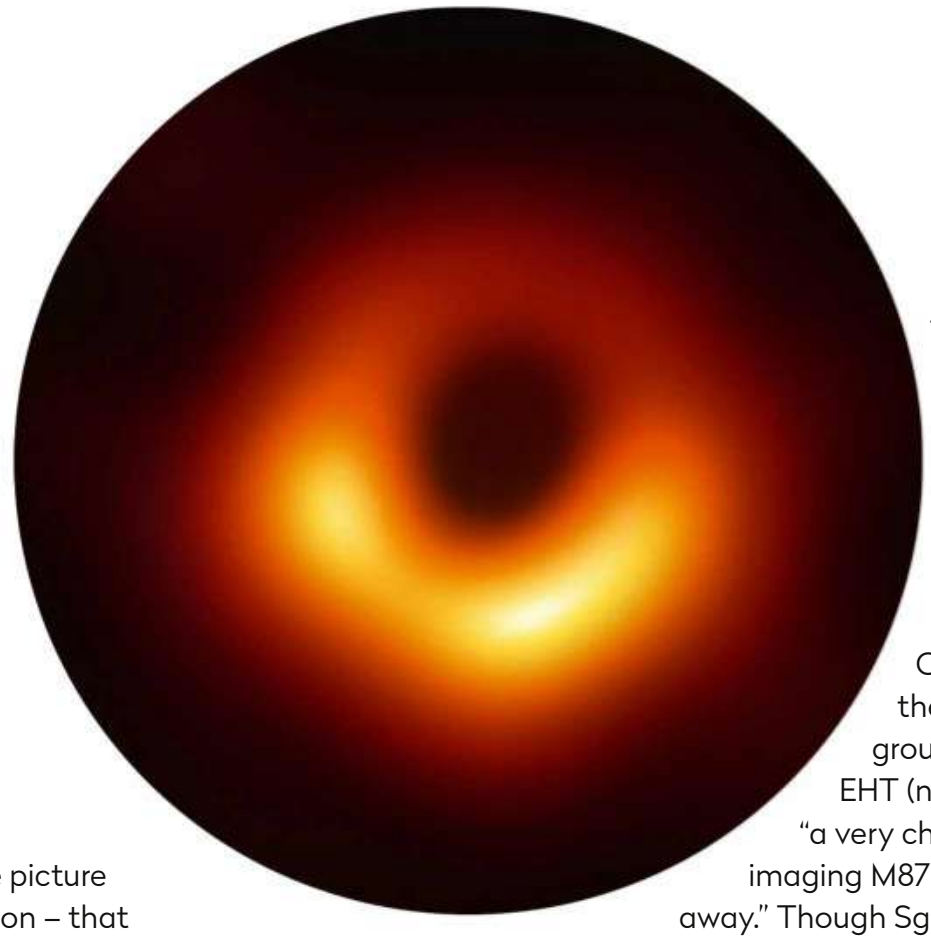
THE DARK HEART of our Galaxy

Jane Green looks into how eight telescopes came together to capture the shadow of Sagittarius A*, the supermassive black hole at the centre of the Milky Way

At last, the mystery at the heart of our Milky Way Galaxy has been uncovered. On 12 May at 13:07 UT, the first ever direct visual image of our closest supermassive black hole was unveiled by the Event Horizon Telescope (EHT) team. It was a thrilling, profound moment.

Though not the first black hole picture presented by the EHT collaboration – that accolade belongs to M87* first presented in April 2019 – it was one long sought after. As nothing, not even light, can escape beyond a black hole's event horizon, they are impossible to see directly. Instead, for decades, astronomers have attempted to track it down by looking for giant stars circling an otherwise invisible point in space. Now we have its image or, more accurately, its silhouette. Our Galaxy's 'central engine' exists.

Over five nights in April 2017, astronomers observed Sgr A* (pronounced "sadge-ay-star") in the constellation of Sagittarius with eight radio telescopes, at six sites from Arizona to the South Pole and Spain to Hawaii. Part of the EHT collaboration – a global network of synchronized radio dishes yielding an Earth-sized virtual telescope of planet-wide aperture – it was the result of decades of work involving more than 300 people and 80 institutions. Using the technique of very long baseline interferometry, the EHT offered the highest possible resolving power from the surface of Earth, capturing objects as small as 20 micro-arcseconds on the sky – that's equivalent to spying a doughnut on the Moon.



▲ M87*, the first black hole to be pictured back in 2019 by the Event Horizon telescope

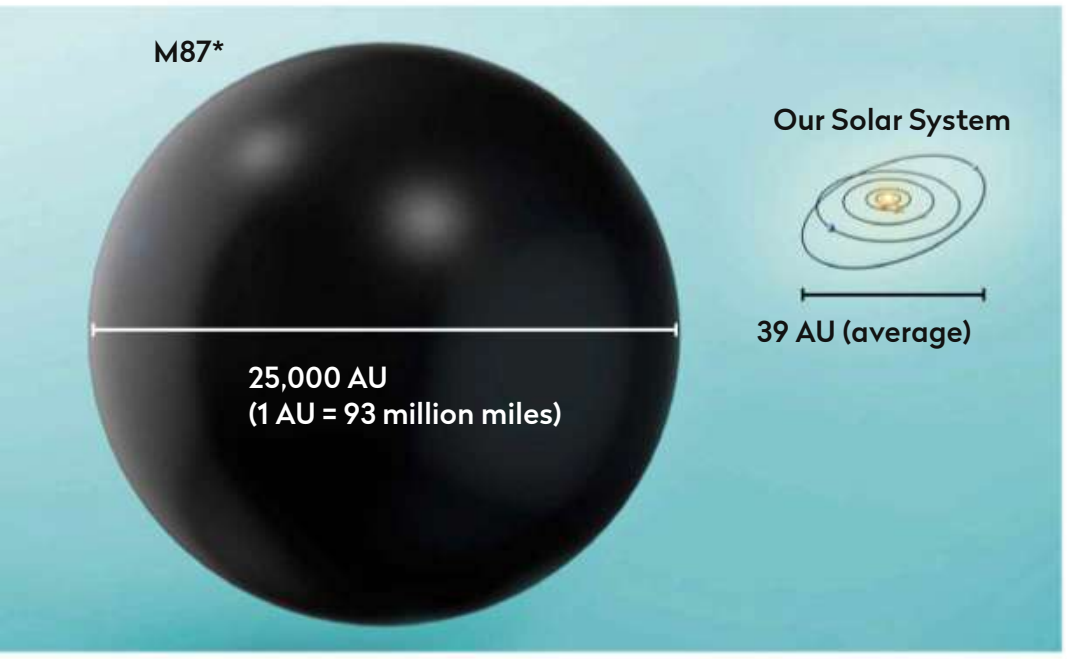
Dr Ziri Younsi from University College London is co-lead of the Fundamental Physics working group on the next generation EHT (ngEHT). He affirmed it was, "a very challenging task compared to imaging M87* located 53 million lightyears away." Though Sgr A* is much closer than that, it is comparatively tiny, with a mass of four million Suns crammed into a region smaller than Mercury's orbit – 1,500 times smaller than M87*, a behemoth weighing in at 6.5 billion Suns. For size comparison, if M87* was the size of Wembley Stadium, then Sgr A* would be a burger at the concession stand.

EHT COLLABORATION X 2, SAO/CRAZYBRIDGE STUDIOS X 2,

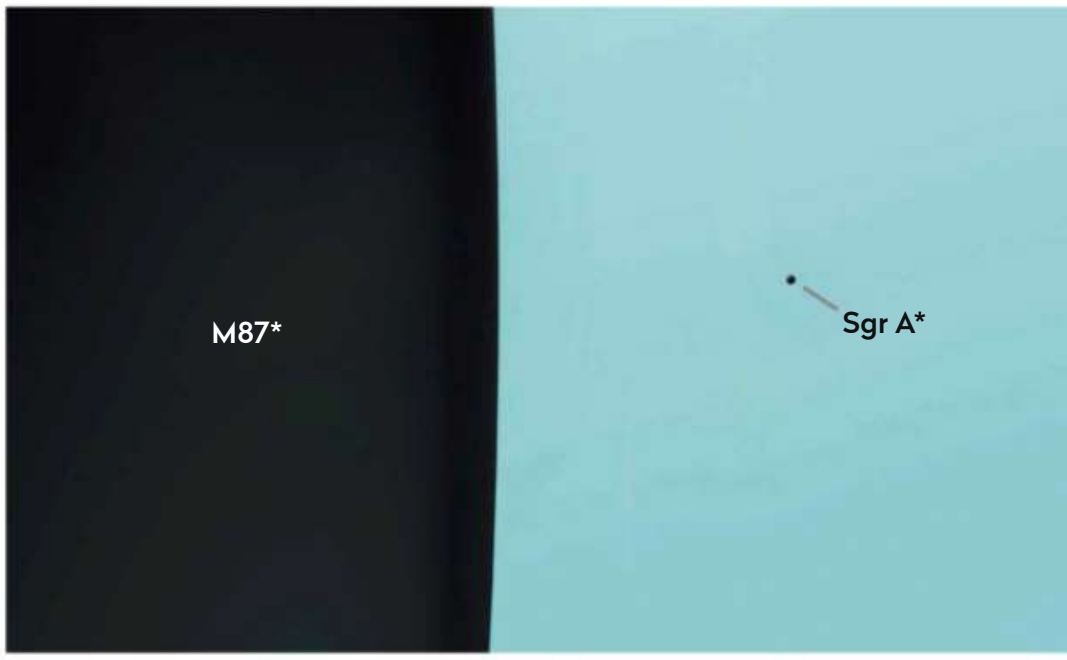
Jane Green is an astronomy writer and author of the *Haynes Astronomy Manual*

Puppy-dog tales

"Gas circling Sgr A* and M87* moves at the same speed – almost the speed of light – but it circuits Sgr A* in a few minutes compared to M87*'s days," says Younsi. "Observing Sgr A*'s turbulent gas flow, minute-by-minute, created 'motion blur'. Moreover, we were looking through the entire Galactic plane stuffed with stars, gas and dust, all rapidly-changing over different timescales. This created a screen of scattered radio waves. Trying to see Sgr A* was like standing in your garden in a rainstorm peering through a steamed-up kitchen window watching



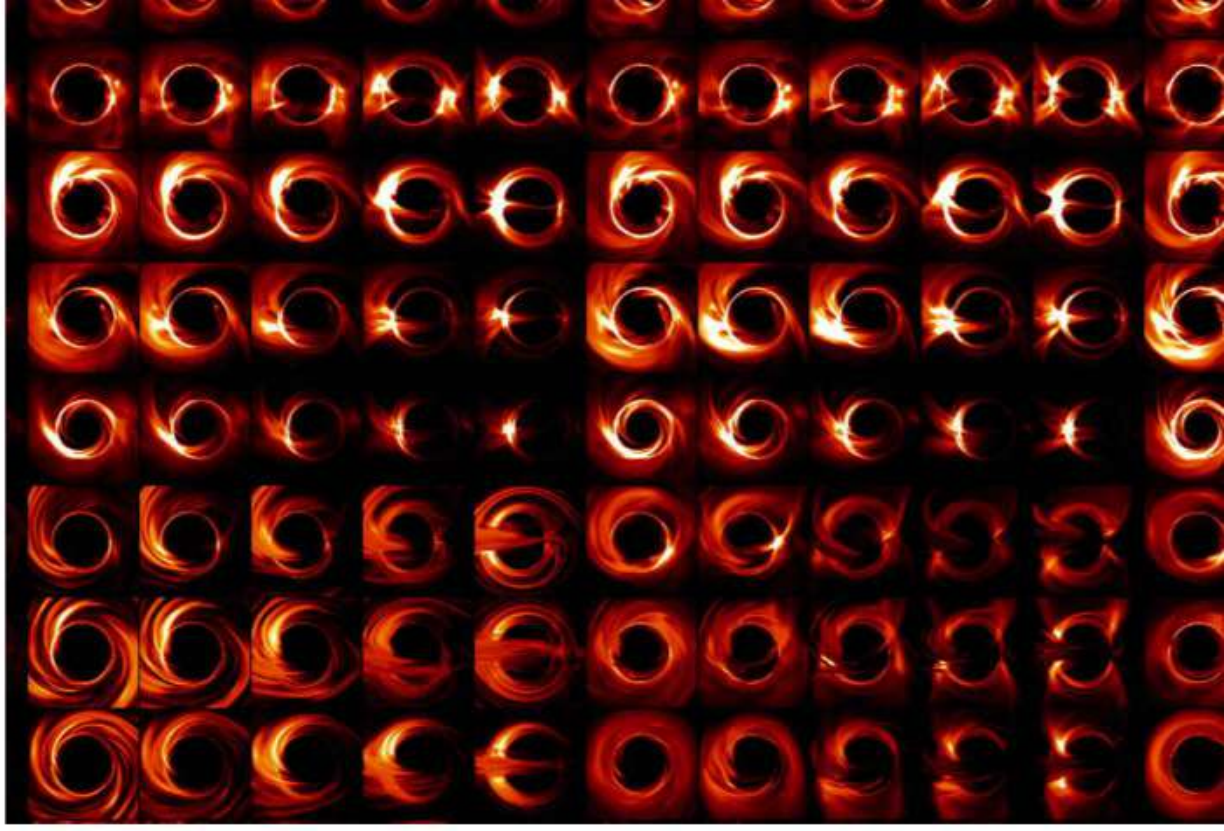
▲ To illustrate the huge difference in size between the two imaged black holes, M87* is approximately 25,000 AU across, whereas Pluto orbits the Sun at an average of 39 AU...



▲ ...this means it dwarfs our own galaxy's black hole which is a tiny spec in comparison at 32.2 million miles in diameter, or about one third of an AU, not far from the 29-million-mile orbit of Mercury

your frantic puppy – our supermassive black hole – careering around in circles chasing its tail! By comparison, M87* is a puppy napping on a sunlit patio!"

It has taken five years for the EHT team to figure it all out. It was a daunting task: collaboration members split into multiple teams, each using independent methods to reconstruct an image from the data. The result was uncertain; many images revealed a ring, but not all. To solve this dilemma, scientists used some of the most sophisticated computer algorithms ever written to simulate different images, and then used these to test what results their various image reconstruction methods would give. Eventually they were certain they had detected a ring, and what a spectacular, ground-breaking result!



▲ The EHT Collaboration created a series of possible images of Sgr A* using ray-tracing based on Einstein's Theory of General Relativity

EHT's vision – three million times sharper than the human eye – revealed Sgr A* is strikingly similar in its overall morphology to M87*. There is a bright fuzzy ring of light – radio emission from electrons in the ►

The Event Horizon Telescope

The EHT is a planet-wide network of 11 synchronized radio telescopes

2017 observing campaign telescopes:

1. Atacama Large Millimeter Array (ALMA), Chile.
2. Atacama Pathfinder Experiment (APEX), Chile.
3. IRAM 30-m Telescope, Pico Veleta, Sierra Nevada, Spain.
4. James Clark Maxwell Telescope (JCMT), Hawaii, USA
5. Submillimeter Array (SMA), Hawaii, USA.
6. Large Millimeter Telescope (LMT), Alfonso Serrano, Mexico.
7. South Pole Telescope (SPT).
8. Submillimeter Telescope (SMT), Mount Graham, Arizona, USA.

Additional telescopes since 2017:

9. IRAM NOEMA Telescope, French Alps.
10. Greenland Telescope (GLT)
11. University of Arizona 12-meter Telescope, Kitt Peak, Arizona, USA.

Building an Earth-sized telescope

By working together, the EHT can see far more detail than the sum of its parts

Staff at the Max Planck Institute for Radio Astronomy evaluate data from the EHT

The technique of very long baseline interferometry combines data from pairs of EHT telescopes to reveal both the small- and large-scale structure of the target.

The varying distances between the telescopes – known as the baseline – means they receive the signal from the black hole at slightly different times, which can be measured using very accurate clocks. As the planet turns, each telescope's view of the Galactic centre changes, as do the dishes' apparent separations as seen from the black hole. Such changes help 'fill in' the virtual antenna. To compile the image, a variety of baselines are needed, and the more the merrier.

The enormous volume of raw recorded data (3.5 petabytes, equivalent to 750,000 DVDs) from each EHT site is stored on high-performance helium-filled hard drives and transported by commercial freight aircraft to highly specialised supercomputers known as correlators at the Max Planck Institute for Radio Astronomy (MPIfRI) in Bonn, Germany and the Massachusetts Institute of Technology's (MIT) Haystack Observatory in Massachusetts, USA, where it is combined and calibrated to within trillionths of a second.

▸ gas swishing around the black hole – encircling a dark centre. This dark core is where the light, captured by immense gravity, has plunged past the event horizon never to be seen again, but leaving a 'shadow' of the black hole's presence. Sgr A*'s appetite compared to M87* is surprisingly slow; it is effectively starving, surviving on whispers of gas from the winds of nearby stars – comparable to a human swallowing one grain of rice every million years. The infalling gas emits just a few hundred times as much energy as our Sun, so at a cosmically 'close' 27,000 lightyears, Sgr A* cannot be considered bright.

Einstein wins again

The measurement also allowed astronomers to measure the size of Sgr A*'s event horizon, which according to Einstein's theory of gravity should be directly related to its mass. The EHT measured Sgr A*'s event horizon spanning around 51.8 micro-arcseconds, precisely as the theory predicted.

But there are still several mysteries our black hole might be hiding. Sgr A* lies on its side so that we look down at its head, and it is spinning counter-clockwise at a yet to be determined rate in the same direction as its orbiting gas. This orientation may hide a relativistic jet. And the bright knots dotting the ring? These could be areas rich in gas, or artifacts from the observation process – it will take more work yet to determine what these mean.

In fact, producing the image is just the start. Subsequent observing campaigns have generated data that also requires analysing. More dishes are being added to the telescope between now and 2030 to create the ngEHT. This will expand the current 230 GHz radio frequency to 345 GHz, improving image resolution by 50 per cent. Movies will showcase how black hole silhouettes change over time, the 'slower' M87* offering a possible 'world premier'. Who knows? Within a decade we may enjoy videos of Sgr A* in action.

As Dr Younsi so eloquently stated, "black holes play a fundamental role in the genesis of the Universe, our Galaxy and every other galaxy. They are the bedrock, the gravitational anchors holding everything together so it's remarkable that we can actually see them now".

Remarkable indeed, and so much more science is still to come!

▼ **Studying black holes could shed light on the beginning, and end, of the Universe**

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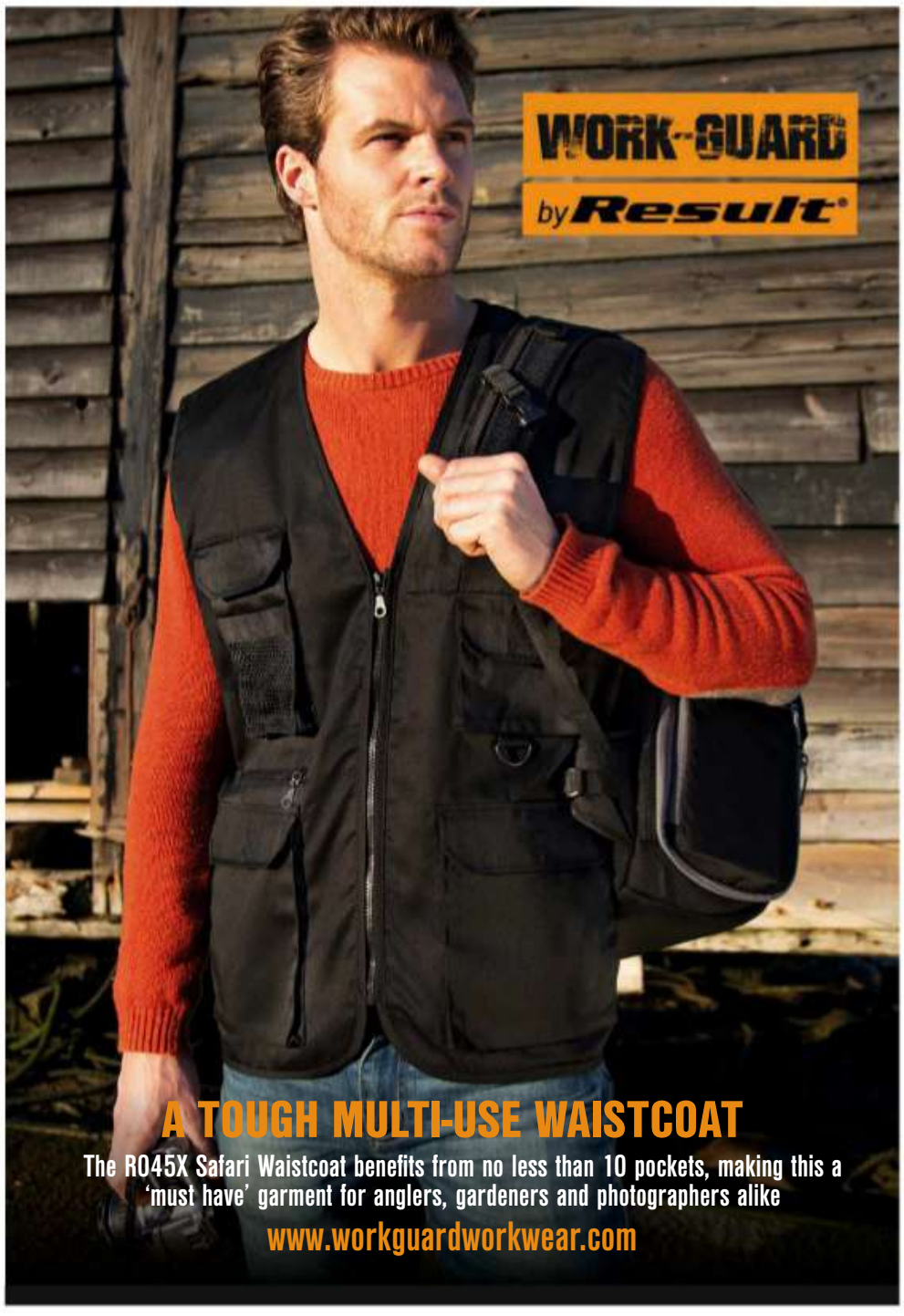

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The fundamentals of astronomy for beginners

EXPLAINER

Meteorites, messengers from other planets

Stuart Atkinson takes a look at five of the most famous 'celebrity meteorites'

2013: the Chelyabinsk meteorite left a smoke trail in its explosive wake; Inset: a fragment of the space rock itself

We would be amazed if we could look up at the night sky and see all the rocks flying through space around us. Our Solar System contains billions of them, all orbiting the Sun – like miniature worlds. Occasionally, Earth crosses paths with one of these meteoroids and it burns up in our atmosphere as a meteor or shooting star. But some survive their fiery passage and land on the ground as a charred rock. Most of these are never found, but a few are seen to fall and then are recovered to be studied by scientists. All these meteorites are fascinating, but some are more valued by scientists and collectors. One might even say they are 'celebrity meteorites'. Here, we look at five of these most famous space rocks.

The Winchcombe meteorite

Late on the evening of 28 February 2021, thousands of people across the UK and northern Europe saw a bright fireball streaking across the sky, and some of them heard sonic booms. The fireball was also recorded by the cameras of the UK Fireball Alliance (**www.ukfall.org.uk**), a network of cameras scattered across the UK. By combining the eyewitness reports and analysing the survey images, experts calculated that meteorites may have landed in, or near, the Gloucestershire village of Winchcombe. The next day a hunt began, and before too long dark, fragile rocks were spotted in the grass. One family found a pile of the rocks on their driveway, surrounded by black powder – yet more pieces of what would become known as the 'Winchcombe meteorite'. A rare, carbonaceous chondrite-type rock, it was the first meteorite to be recovered in the UK in 30 years.

▲ 2021: the Winchcombe meteorite was the first to be recovered in the UK for 30 years

The Chelyabinsk meteorite

As the Sun was coming up over the Russian town of Chelyabinsk on 15 February 2013, people were amazed to see a light, brighter than the Sun, crossing the icy blue sky. This 'superbolide' was seen across hundreds of kilometres, caught on security cameras and car dashcams. As it faded it left a milky white smoke trail across the sky – then, with a deafening crack, a shockwave shattered windows, collapsed roofs and bowled people off their feet. After hitting the atmosphere at a speed of 43,000k/h, a near-Earth

ULLSTEIN BILD/ISTOCK/GETTY IMAGES, BJÖRN WYLEZICH/ALAMY STOCK PHOTO, THE TRUSTEES OF THE NATURAL HISTORY MUSEUM, WALTER GEIERSPERGER/ISTOCK/GETTY IMAGES, SIPA US/ALAMY STOCK PHOTO, UNIVERSAL IMAGES GROUP NORTH AMERICA LLC/ALAMY STOCK PHOTO, H. RAAB

1947: metal fragments of the Sikhote-Alin meteorite were strewn over the Siberian mountains

▼ 1969: the Allende meteorite contains dust fragments from the early Solar System

asteroid, weighing more than 12,000 tonnes and around 20m across, had just blown up, 26km high, releasing more than 30 times the explosive energy of the atomic bomb that dropped on Hiroshima.

Many pieces of the stone meteorite were found, including a 654kg chunk that was recovered from a frozen lake. You can buy pieces of this meteorite, but be careful to only use reputable dealers.

The Sikhote-Alin meteorite

On 12 February 1947, a huge metal meteoroid, weighing around 100,000kg, tore through Earth's atmosphere. It finally exploded over the remote Russian Sikhote-Alin mountains with a deafening boom. Moments later the ground below was peppered with jagged fragments of metal, some blasting out craters, others embedding themselves in trees. Around 23 tonnes of material has since been recovered from the area. You can buy two different types of meteorite from this historic fall. Some are rounded, whole specimens, like metal nuggets with a dark fusion crust and indentations called 'regmaglypts' that look like thumbprints in clay. Others are twisted and gnarled scraps of torn metal with sharp edges that look like bomb shrapnel.

Allan Hills 84001 'ALH84001'

Because the dark stones stand out so well on its bright white snow, Antarctica is a great place for meteorite hunting. Every year teams of scientists roam across the frozen continent's ice fields, hunting for space rocks. On 27 December 1984, the scientist Roberta Score spotted a large, dark rock with an unusual black-green colour, which was duly bagged and sent back to a laboratory for study. It wasn't until years later, however, that 1.93kg 'ALH84001' was identified as being from Mars. When scientists peered deep inside it using an electron icroscope in 1996 they saw what looked like fossilised bacteria within its cracks and then, well, everything went a bit crazy. Had they found evidence of life on Mars? Many thought so, and President Bill Clinton even held a media conference to hail the discovery. But other scientists were more sceptical, and more recent research has suggested that the structures thought to be in the meteorite aren't biological.

The Allende meteorite

If there's a Kardashian-class celebrity meteorite then it has to be Allende. On 8 February 1969, as NASA was gearing up for the launch of Apollo 9 – the first crewed test flight of the lunar module – a shower of dark rocks fell from the sky not too far from the Mexican town of Pueblito de Allende. Scattered across an area of 150km^2, these were the pieces of a car-sized meteoroid that had come apart high in the atmosphere. Although the stones – which were very dark on the outside, as black as coal, with a dark grey interior that contained lots of tiny, pale spots and grains, or chondrules – didn't immediately look like anything special, analysis revealed they were pieces of a very rare type of ancient and primitive carbonaceous chondrite meteorite. Indeed, those chondrules contained dust grains that dated back to the Solar System's birth.

▲ 1984: the 'ALH84001' meteorite (left), discovered in Antarctica, was initially thought to contain evidence of microbial Martian life (right), but this has since been disputed

Stuart Atkinson is a lifelong amateur astronomer and author of 11 books on astronomy and spaceflight

DIY ASTRONOMY

How to build a webcamscope

Construct a simple and cost-effective imaging device for capturing bright targets

▲ **Once it is set up, the webcamscope (above) lends itself to bright, easy-to-locate targets like the Moon (inset)**

A webcamscope provides a simple and cheap introduction to astrophotography. As its name suggests, it's built around the sort of webcam you might buy for Zoom meetings, rather than a DSLR camera.

The components you need to make a webcamscope are widely available and, whether you choose brand-new or second-hand parts, they won't cost much. You may even have some of them in a spare drawer. I paid £11 for the webcam and £16 for the 200mm M42 lens on eBay, while the eyepiece adaptor, which replaces the webcam's lens, was £10.

Second-hand M42 lenses are commonly available and, as they use a screw thread rather than a bayonet fitting, you can make a mount for one from an old rear lens cap. Lenses can be heavy, though, so you can adapt the wooden mount to incorporate a cradle to support the front part as well.

When building your webcamscope, it's important to get the correct distance between the backplate of the lens and the surface of the sensor in your webcam (the registration distance). For M42 lenses, the registration distance is 45.5mm. If you vary this by too much, you might not be able to focus. I drilled a 32mm-diameter hole through the wooden mount to hold the webcam adaptor, with a wider recess for the M42 rear lens cap, so the webcam and camera lens were held close together. A little masking tape wrapped around the adaptor stops it slipping out.

Once set up, you shouldn't need to make big changes to the focus, but it helps to be able to turn the lens's focus ring if you shift targets. Cutting away the sides of the wooden mount will make it easier to access the ring. A metal strip with a ¼-inch hole allows the mount to be fixed to a tripod. Position this once you've established the balance point of the assembled instrument, to reduce any tripping potential.

Get creative

To create an image, you'll need to capture a video clip. You can use a Windows computer (SharpCap, **bit.ly/3w5mkNS**) or a Mac (oaCapture, **bit.ly/3vFdc3w**). Once you have a clip you can use stacking software to align and stack the best frames from the video, as well as to remove any noise, and produce a high-quality, still image. Lynkeos (**bit.ly/3w1BGTq**) is a stacking application for Mac, while RegiStax (**bit.ly/3MOljPH**) is popular for Windows.

Using this webcamscope is as easy as making it – point, focus and record a video clip. Experiment with different exposure settings to see which clips are better to process. You'll become addicted.

Mark Parrish is a bespoke designer based in West Sussex

MORE **ONLINE**

Download a plan and additional photos to help with your build. See page 5 for instructions

What you'll need

▶ Marking-out tools (a ruler, compasses and a pencil); a coping saw (or drill and hole saws).

▶ Plywood or softwood, approximately 600mm x 80mm x 15mm (or 12mm); a small strip of stiff metal (approximately 100mm x 25mm x 3mm); small screws; wood glue; and paint.

▶ M42 camera lens (with a focal length of 200mm or similar); an M42 screw cap; a webcam (and a laptop); a 1.25-inch webcam eyepiece adaptor.

ALL PICTURES: MARK PARRISH

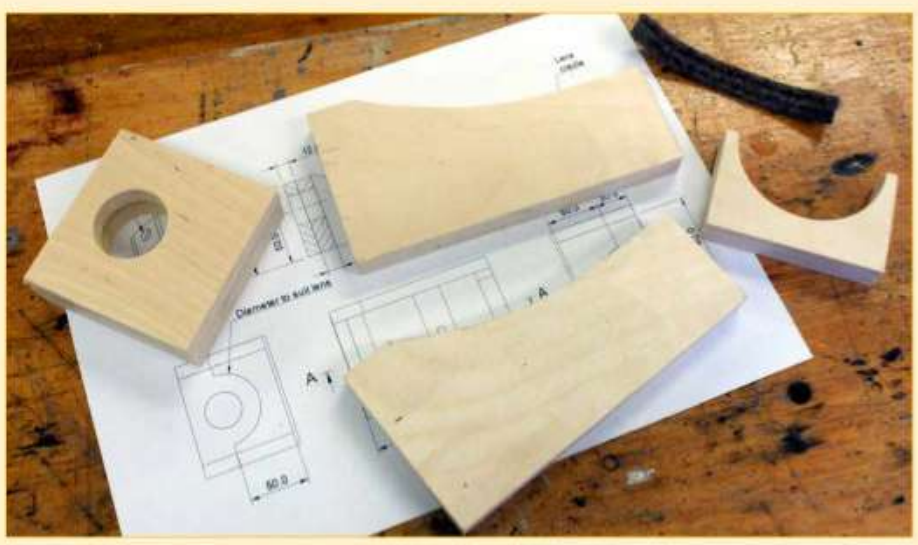
Step by step

Step 1

Unscrew and remove the built-in lens unit of the webcam: some cases just prize apart, while others have small screws. You can also remove the stand/clip (but you don't need to for this project) and you may need to enlarge the hole in the casing to fit your adaptor.

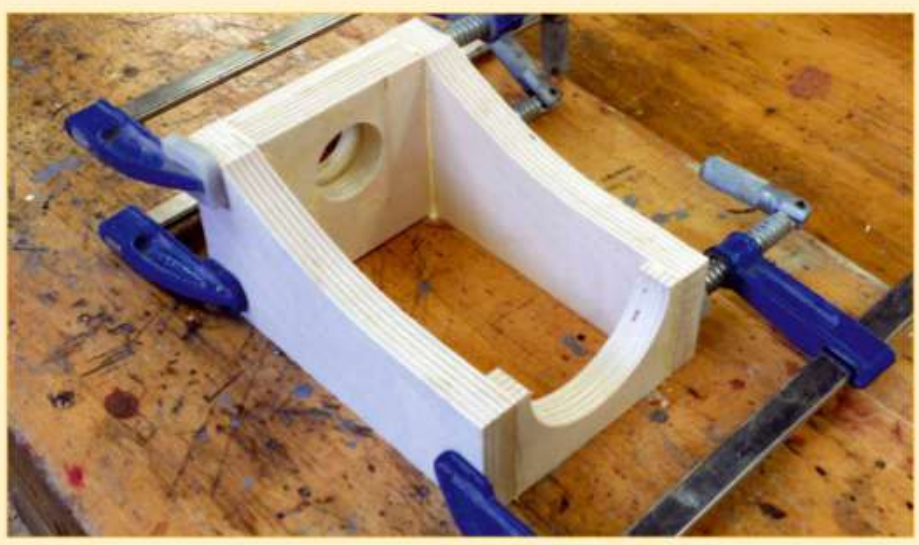
Step 2

Your adaptor might screw into the old lens thread. If it's an odd size you may be able to use the metal adaptor's internal thread to screw it onto the smooth outside of the plastic lens fitting. It's important to align it above, and perpendicular to, the sensor.



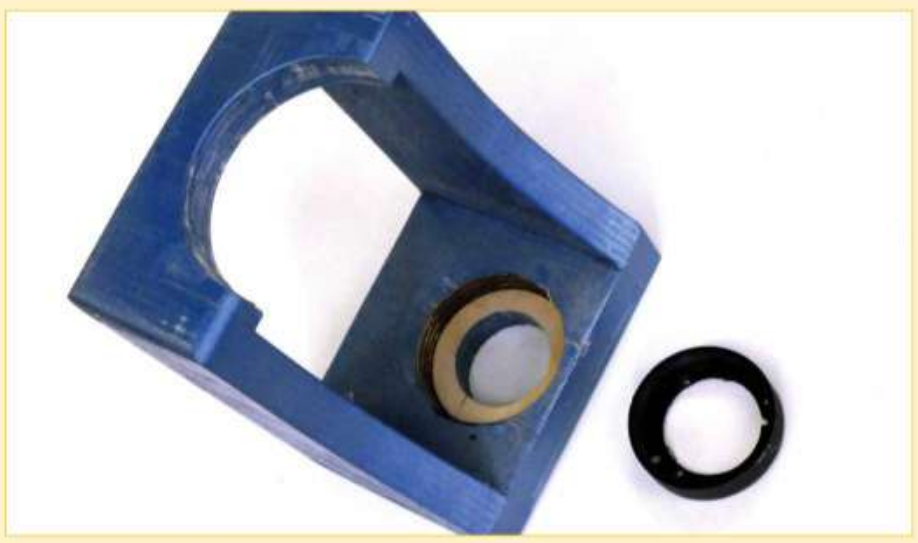
Step 3

Download and print the webcamscope plan (see 'More online'), and mark out the parts for the mount on the wood and cut them out. Adjust the cradle at the front and the overall length of the mount to fit your lens. It needs to be held so you can still focus.



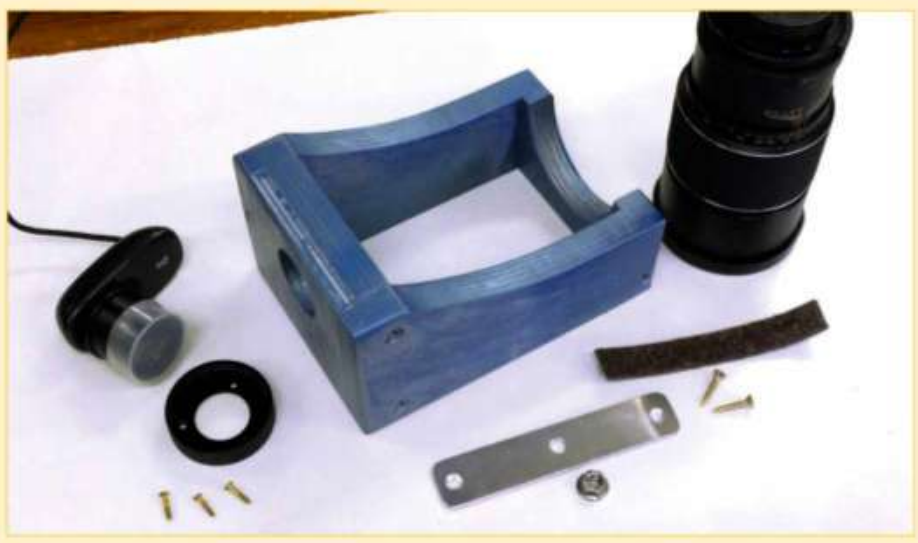
Step 4

Once you're happy with how your lens fits in your mount, glue and clamp the parts together. Use pilot holes if you're going to add screws to stop the plywood splitting. Once the glue is dry, smooth the surfaces down with sandpaper and give them a coat of paint.



Step 5

If you find your mount is too thick to achieve focus, you can cut a recess for a modified M42 rear lens cap. You may need to adapt the design a little, depending on the registration distance of your lens.



Step 6

Cut a metal strip to make a bracket to mount the webcamscope to a tripod. Next, assemble the parts. Find the best position for the bracket by finding the balance point of your webcamscope. Use a camera screw, 0.25-inch x 20tpi (thread pitch) to fit it to the tripod.

Take the perfect astrophoto with our step-by-step guide

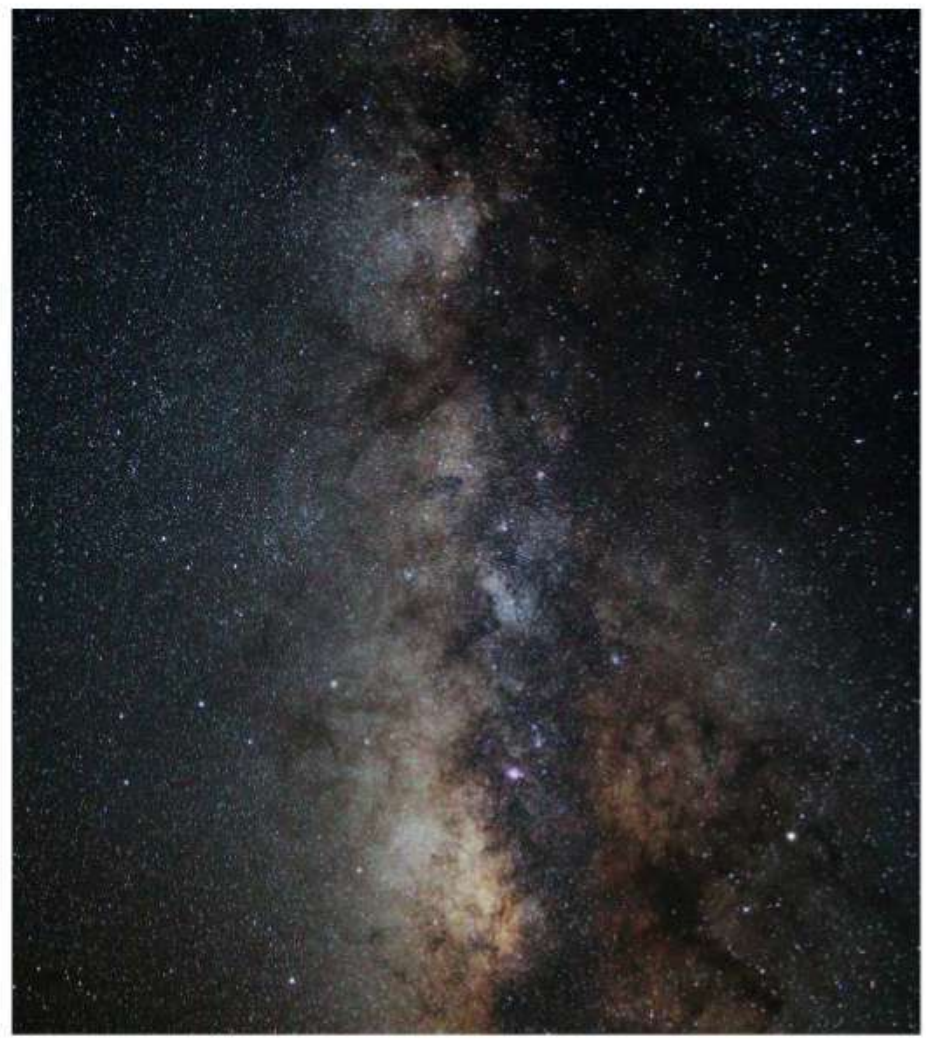
ASTROPHOTOGRAPHY CAPTURE

Photograph the Milky Way

Image the misty glow of our home Galaxy as it crosses the sky during the summer months

The Milky Way represents the plane of our home Galaxy. Its diffuse glow is caused by the light of billions of stars too distant to be seen individually with the naked eye. As our Galaxy is shaped like two fried eggs back-to-back, and the Sun sits within the 'whites', two-thirds of the way from the centre, the mistiness appears like a path in the sky; the plane where all the stars are found.

The path isn't uniform, something very evident at this time of year from a dark sky site. From the UK, the Milky Way brightens as it passes south through the Northern Cross asterism. It's made more dramatic by a dark dust cloud blocking some of the Milky Way's light, known as the Cygnus Rift.



▲ **The Great Rift goes through one wing of Cygnus, and passes the Wild Duck Cluster (M11)**

Dark swans

If your skies are good and dark, it's obvious that as the Milky Way passes out of the southern end of Cygnus, interesting things are happening. However, from the UK, its low altitude makes seeing this quite difficult. Passing down into Sagittarius, we reach the bright core of our Galaxy. Here atmospheric extinction reduces its appearance but a camera can help restore at least some of its impact.

As it flows south through Cygnus, one portion meanders towards the northeast corner of Ophiuchus where it comes to an end. The main thread passes down through Aquila and into Scutum where there's a bright feature, the Scutum Star Cloud. It then appears to widen, an effect caused by the core bulge. From locations further south where the core is able to climb high in the sky, it can be impressive, even casting blurry shadows under the right conditions.

From the UK, its low altitude means we see it through a thick layer of atmospheric haze. For the best views, you will need a location which is dark and free of light pollution. A flat southern horizon is highly recommended. These conditions are often met by south facing coasts, though they can be achieved inland.

Choose a moonless night, and time your session for when the Milky Way's core region is high in the sky. The last week of July until 4 August and 20 August until the end of the month are good this year. The core can be photographed using a camera on a static mount, and even certain smartphones. However, the best results will come from a DSLR/MILC with a medium- to wide-angle lens on a tracking mount.

You'll need to do some processing to get the best out of the results, and you need to consider shooting at low to mid-low ISO values. Go too high and the amplification nature of ISO will work against you, delivering shots that will degrade rapidly when pushed. However you do it, July and August are great months to capture the beauty of our galaxy.

Pete Lawrence is an expert astro-imager and a presenter on *The Sky at Night*

Equipment: Tripod or tracking mount; DSLR, MILC or night-sky capable smartphone; remote release

✉ Send your images to:
gallery@skyatnightmagazine.com

ALL PICTURES: PETE LAWRENCE

Step by step

STEP 1

Choose a location with as low and flat a southern horizon as possible. The night sky will be relatively bright at the start of July, so you have plenty of time to find a suitable location. You'll also need to get as far from light pollution as possible, avoiding direct lights in view. A south- to southwest-facing coast can be ideal.

STEP 2

A wide-field lens, say of 12-14mm focal length, will cover a large area in portrait orientation; the horizon to the Summer Triangle. Alternatively, choose a longer focal length to home in on specific bright regions such as the Scutum Star Cloud, useful if you have bad light pollution at low altitude.

STEP 3

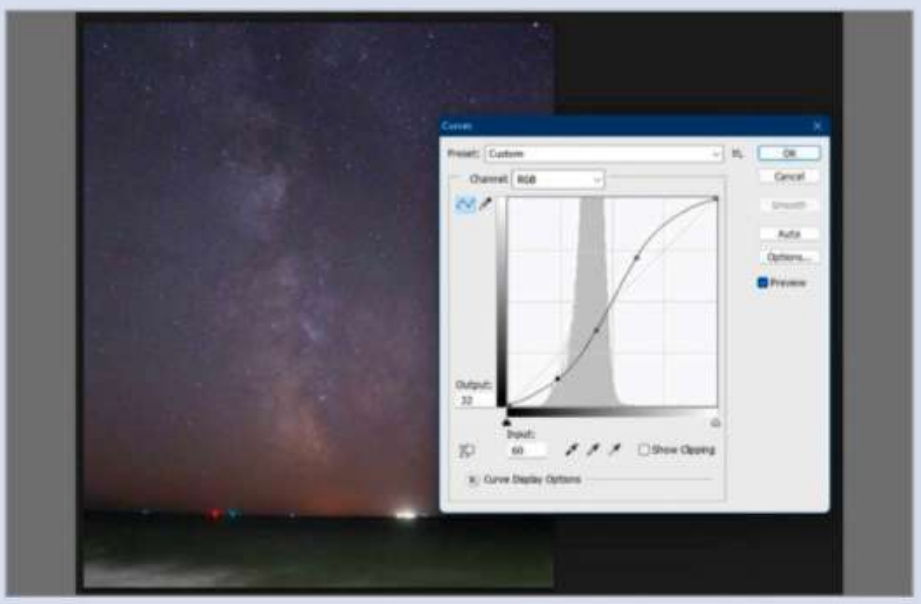
Use a tripod for stability. If you have a star tracker, this is ideal. If you're planning to use a smartphone, some have the capability to take night shots while handheld, but a cheap tripod mount will yield the best results. If you're planning to set up on the coast, remember beach locations can get quite windy, so find a sheltered spot.

STEP 4

If using a static tripod, select a mid to high ISO value. If using a tracking mount, select a low to mid value. Fully open the lens (lowest f-number). If a test shot shows distortion at the frame edge, consider closing the lens by a stop or two. A remote shutter release is recommended to keep the camera still when activating the shutter.

STEP 5

Focus as accurately as possible. Using Live View on a bright star such as Altair (Alpha (α) Aquilae) or a planet should be fine for this. Take a 10-second test exposure and examine the result. If you use a tracking mount, aim for 30-60 second exposures, longer if your polar alignment is good enough to allow.



STEP 6

Download and select your best shot, then load them into a layer-based editor. For a quick image fix, use Levels, dragging the mid-slider so it's under the main histogram peak. Apply a gentle Curves 'S' adjustment and apply 'auto-colour'. Finish off with a tweak to the brightness and contrast adjustment settings.

Expert processing tips to enhance your astrophotos

ASTROPHOTOGRAPHY PROCESSING

Removing stars from a deep-sky nebula target

Use a Photoshop plug-in to eliminate stars in an image of the Statue of Liberty Nebula

With the exception of targets like open clusters, stars are generally not the main feature of astro images. In fact, their presence can hinder us from teasing out nebulae and similar objects of interest. While some programs, like Photoshop, offer techniques to partly get around this, a new plug-in makes it much easier. In this article, I will look at the benefits of using StarXTerminator.

The plug-in StarXTerminator, by Russell Croman, has been trained to recognise and eliminate stars from an image, by using 'machine learning' (artificial intelligence). Once these have been removed, the image can be processed with full attention paid to the target. When the processing is complete, the stars can be put back in, or left out (see images, above).

The starless software revolution itself began with StarNet++, a free script for PixInsight. Several years later, StarXTerminator, a commercial plug-in, built by Croman's RC Astro, was introduced for Photoshop (and PixInsight). The software is compatible with Windows, macOS and Linux operating systems, and a free 30-day trial is offered (see **www.rc-astro.com/resources/StarXTerminator**).

▲ Left: a starless image of NGC 3576 shows why the technique of omitting stars during processing can bring out vivid nebulosity in narrowband images...

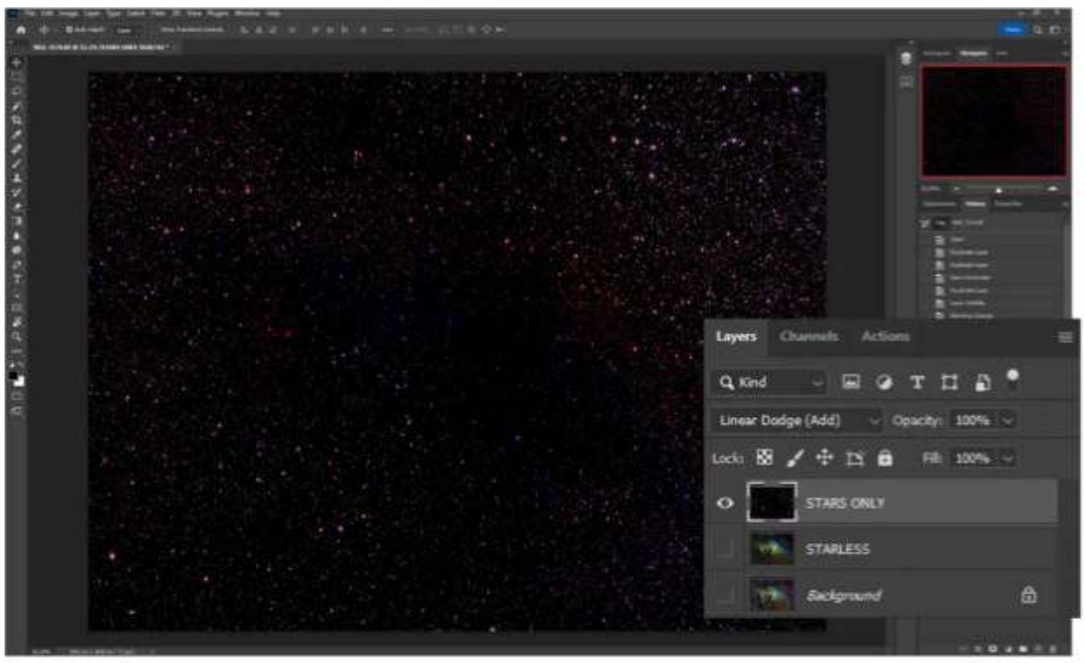
Right: ... and you still have the option of adding the stars back in

Why are stars such a challenge? For starters they are already bright, so you can damage them by 'stretching' (boosting) dimmer elements of the picture. Also, unlike the rest of the image, stars do not require sharpening or noise reduction – the removal of unwanted artefacts. If you are trying to process nebulae that lie within the Milky Way, it can be tricky to enhance their dim tendrils due to the stars in the field. You'll find that removing the stars makes processing so much easier.

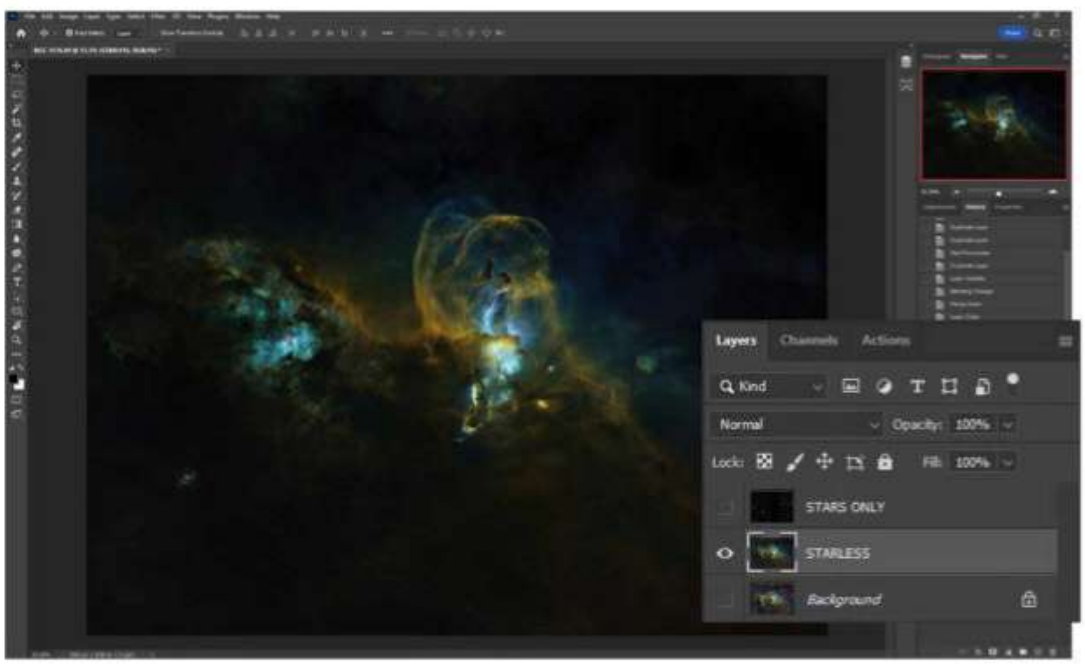
Making life easier

In the past, the process of separating stars from the rest of the image was achieved by using a 'mask'. Think of the way a house painter uses masking tape to protect wood trim where new colour is unwanted. Likewise, applying a virtual mask to an image allows the processor to protect specific elements (eg, stars), so that work performed on other elements doesn't adversely affect them. This may include noise

ALL PICTURES: WARREN KELLER



▲ **Screenshot 1: the topmost layer of the stack contains only the image's stars**



▲ **Screenshot 2: the 'Starless' middle layer can be enhanced with various adjustments and filters to accentuate the deep-sky target**

▲ **Screenshot 3: a contrast-enhancing 'Curves' adjustment to the 'Starless' layer can make the nebula pop**

reduction, sharpening and colour saturation. While masks do this quite well, Photoshop doesn't offer a way to make a star mask. In the past, Photoshop 'Actions' – automated sets of procedures – could be created by advanced users to select the stars, but these involved multiple iterations of several processes and only did a fair job. The StarXTerminator plug-in for Photoshop removes stars at the press of a button!

3 QUICK TIPS

1. Drag and drop the background layer to the '+' sign in the 'Layers' panel (twice) to duplicate it before applying StarXTerminator.

2. If your final image will be starless, you can apply StarXTerminator directly to it without the need for additional layers.

3. Photoshop's 'Clone Stamp Tool' or 'Spot Healing Brush Tool' can eliminate any large stars or halos that remain.

After purchasing or downloading the free trial of StarXTerminator, the files must be placed in Photoshop's 'Plug-ins' folder per the instructions in the included PDF. After opening the plug-in within Photoshop's 'Filter' menu ('RC-Astro') and entering the key sent by email, you'll need to download the latest version of the neural network by clicking 'Download AI'. At the time of writing, Version 9 had just been released. With each revision, the neural network is trained further with image data from different optical systems. This makes the program better at recognising stars of all shapes and sizes, and preventing damage to non-stellar structures.

While it's recommended that you run StarXTerminator in the workflow, it does a great job at any stage, even on final images. With a TIFF image open in Photoshop, you can duplicate the background layer twice.

From the 'Filter' menu, run StarXTerminator on the top layer. Duplicate this layer, then make it invisible by turning off its 'eyeball' icon. Next, set the lower, duplicate starless layer's blend mode to 'Subtract', and merge this layer with the one below using the keyboard command 'Ctrl + E', or the 'Merge Down' command in the 'Layers' menu. This is now the layer with the stars alone. Next, drag it to the top and set the blend mode to 'Linear Dodge (Add)' (Screenshot 1).

You should now have three layers: the original 'Background' photo (bottom), the 'Starless' version (middle) and the stars themselves, 'Stars only' (top). To work on the 'Starless' layer, activate it by clicking on it, and be sure the 'eyeball' icon is switched on. You may wish to briefly turn off the 'Stars only' layer to get a better look at what you're doing (Screenshot 2).

With the stars out of the way, the nebula or galaxy in the middle layer can be enhanced in various ways. Screenshot 3 shows a 'Curves' adjustment, which is used to boost a nebula's brightness and contrast.

When the processing is complete, the layers are 'Flattened' to include the stars, or not: it's your choice!

Warren Keller is an astrophotographer and image-processing educator. See **www.mastersofpixinsight.com**

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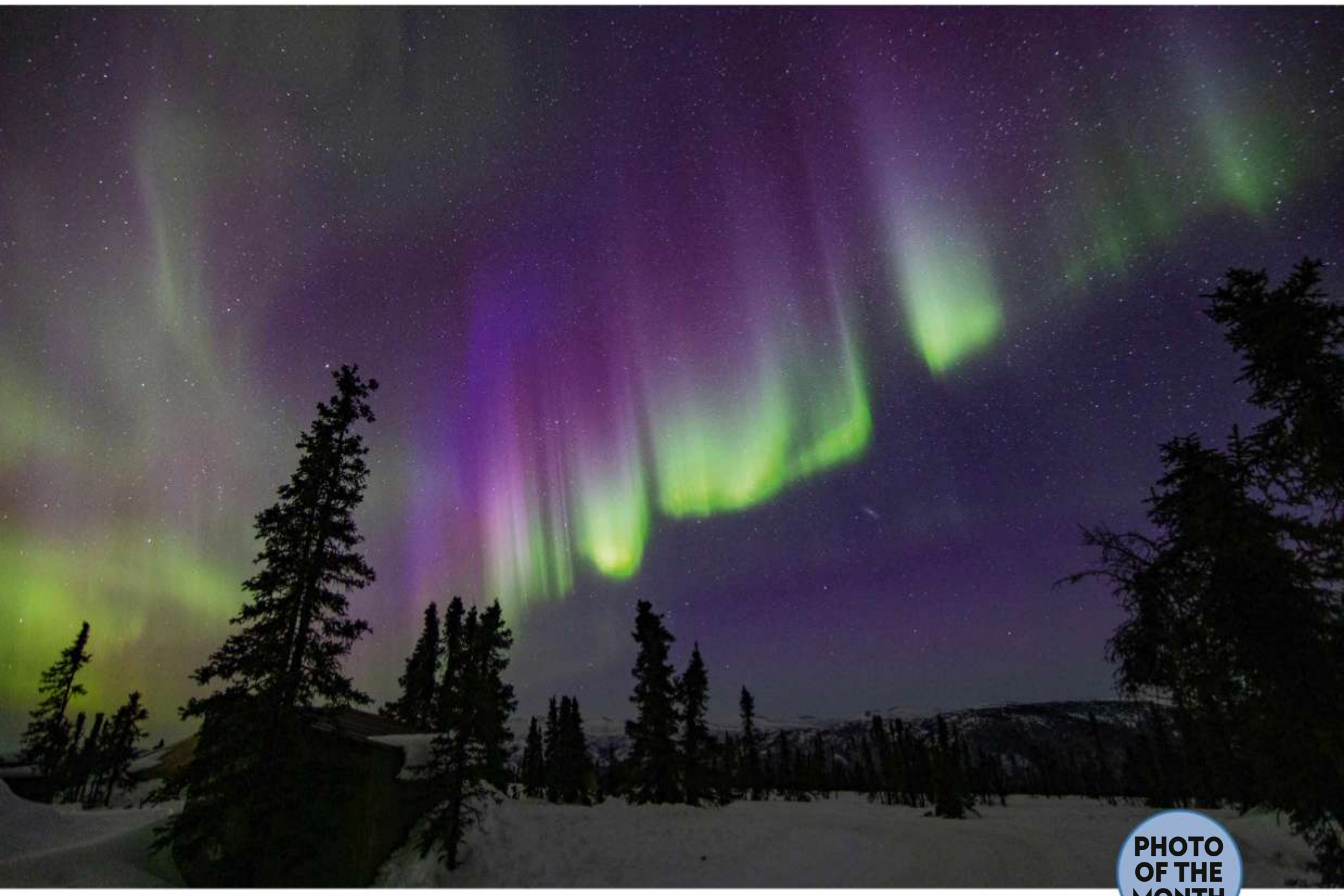


PHOTO OF THE MONTH

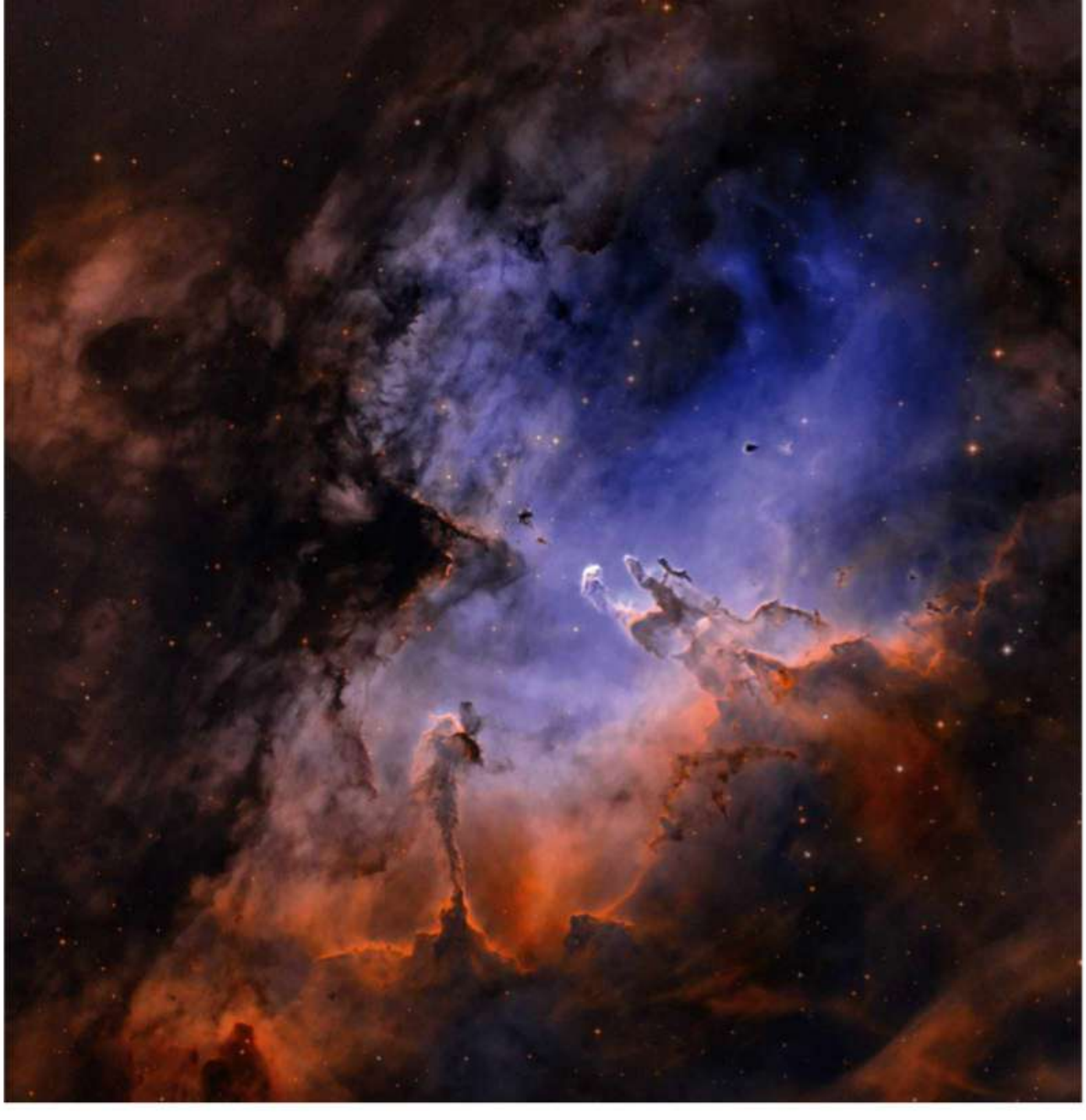
△ Aurora streamers over the White Mountains

John Chumack, Chena River Recreation Area, Alaska, 31 March 2022

John says: "I love the dark skies here. I could easily see several deep-sky objects with the unaided eye, including the Andromeda Galaxy, M31, which you can spot just below the green 'piano keys' in this shot. It's usually almost –30°C here, but this year it was actually –8°C. This was much better for my camera batteries, which didn't drain as fast."

Equipment: Canon 6D DSLR, Tokina 16-28mm lens, Bogen tripod
Exposure: ISO 3200 f/2.8, 6"
Software: Adobe Camera Raw

John's top tips: "To shoot aurorae, it's vital to find a low, dark location with no cities directly to your north. Be sure to mount your camera stably on a tripod, especially on uneven terrain. Avoid touching the camera as this will blur your image; use a remote switch or timer. Choose a wide-angle, fast lens such as 14–24mm and f/1.4, f/2.8 or f/3.5. Exposure times can be as much as 30 seconds, but 5–10 seconds will help keep details sharp. Don't worry about noise (unwanted artefacts). You can either take a dark frame and subtract the noise later or use a 'denoise' tool when you are post processing."



◁ The Eagle Nebula

Diptiman Nandy, remotely via El Sauce Observatory, Rio Hurtado, Chile, 24 August – 19 November 2021

Diptiman says: "I've been doing astrophotography for eight months now. Processing this image was a great challenge."

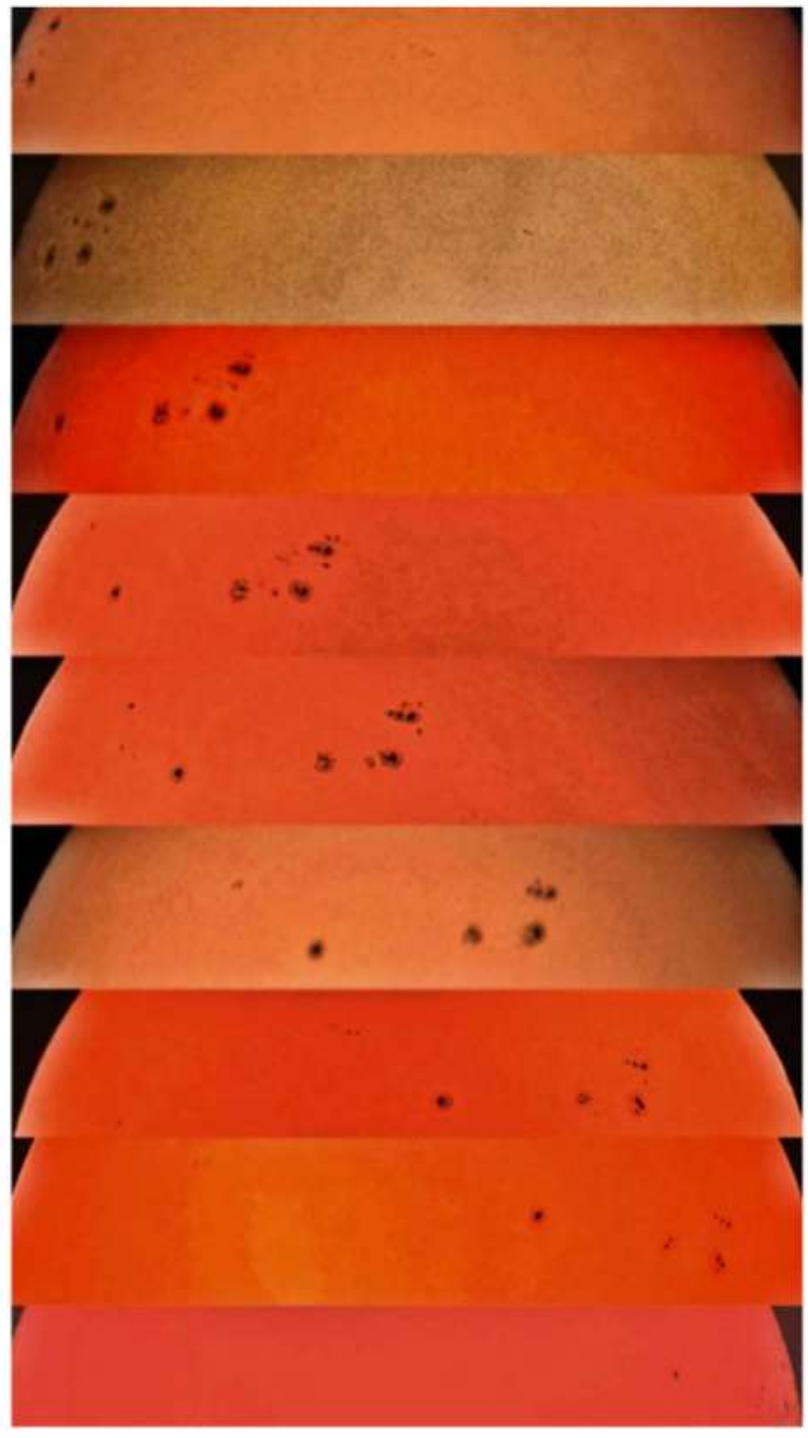
Equipment: FLI ProLine PL9000 camera, PlaneWave CDK24 astrograph, Mathis Instruments MI-1000 Equatorial Fork Mount
Exposure: Ha 22x 600", OIII 25x 600", SII 26x 600"
Software: DeepSkyStacker, PixInsight, Photoshop

Sunspot montage ▷

Peter Lewis, Sutton, London, 18–26 April 2022

Peter says: "This montage captures AR2993–2996 over eight days as Earth rotated around the Sun."

Equipment: Samsung S20 smartphone, Orion SkyQuest 8-inch Dobsonian, Orion solar filter **Exposure:** ISO 50, 1/350"
Software: Google Photo Editor



▽ Crater Plato

Alfonso Merino, Madrid, Spain, 17 April 2022

Alfonso says: "Most of the time my targets are deep-sky objects, but sometimes it's nice to take a moonwalk."

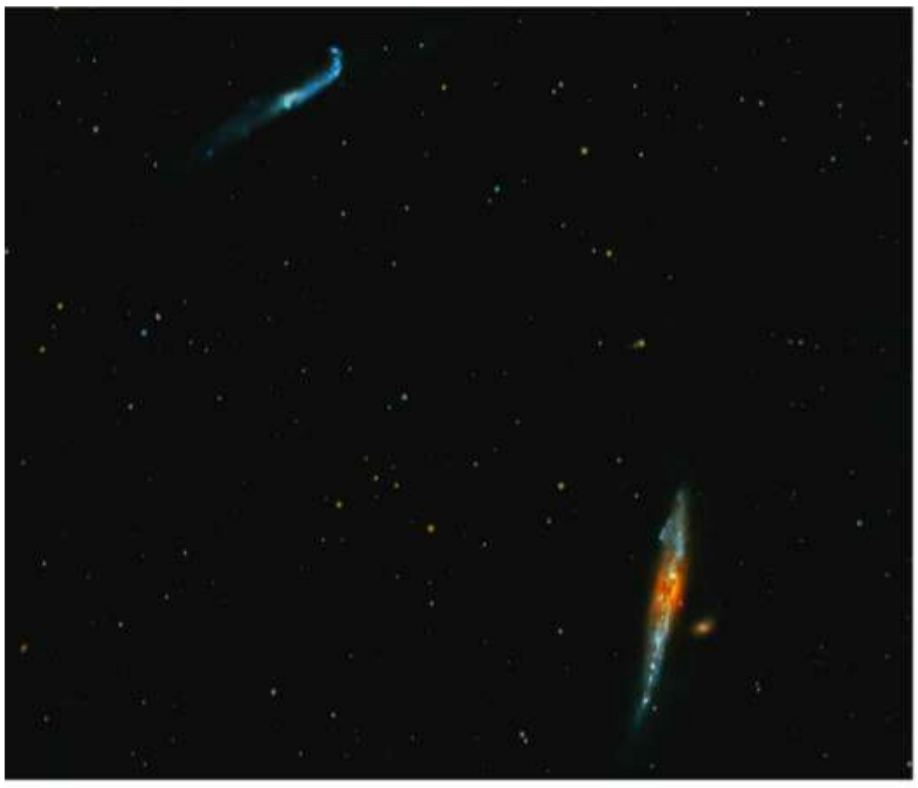
Equipment: ZWO ASI120MC-S camera, Sky-Watcher Skymax 127 Maksutov-Cassegrain, Sky-Watcher NEQ6 Pro mount
Exposure: 180" video **Software:** AutoStakkert!, RegiStax

△ Star trails over a tulip field

Dario Giannobile, Blufi, Sicily, 26 March 2021

Dario says: "Taking advantage of the almost full Moon, I let the stars draw circles above this field of wild tulips."

Equipment: Canon 6D DSLR camera, Canon 8–15mm lens, Manfrotto MT190XPRO4 tripod **Exposure:** ISO 400 f/4, 30" **Software:** Photoshop



△ The Whale and Hockey Stick Galaxies

Michael Clem, Waynesboro, Pennsylvania, US, 30 April & 1 May 2022

Michael says: "This was a tough capture: I had to wait for the galaxy pair to rise high enough to clear power lines. Then I had to throw away an hour of subs due to planes and satellites. Frustrating, to say the least."

Equipment: ZWO ASI533MC camera, Astro-Tech AT115EDT refractor, Sky-Watcher EQM-35 Pro mount **Exposure:** 37x 5' **Software:** PixInsight

△ Partial solar eclipse

Tomás Andonie, Santiago, Chile, 30 April 2022

Tomás says: "I planned ahead for the trajectory of the Sun and luckily had a clear view from my home to take a shot every 10 seconds for the whole hour. The weather was perfect too."

Equipment: Nikon D3300 DSLR, Nikkor 55–300mm lens, Baader solar filter, Sky-Watcher Star Adventurer 2i, K&F Concept tripod **Exposure:** ISO 200, f/5.6, 1/3200" **Software:** Photoshop

◁ The North America Nebula

Kevin Earp, Bedford, 4 May 2022

Kevin says: "The L-eNhance filter on my one-shot colour camera gives me lots of palette options. I chose a false Hubble-style palette to emphasise the beauty of the Cygnus Wall. With only 2.5 hours of total integration, I'm pleased how it turned out."

Equipment: ZWO ASI294MC Pro camera, Sky-Watcher Esprit 100 apo refractor, Sky-Watcher NEQ6 PRO mount, Optolong L-eNhance filter, ASIair Plus controller **Exposure:** 29x 300" sub exposures; gain 120 **Software:** Astro Pixel Processor, Photoshop

The Milky Way ▷

Basudeb Chakrabarti, West Bengal, India, 13 March 2022

Basudeb says: "We reached the remote Namthing Pokhri Lake at 3:45am. It was so dark I couldn't even see my hand. I was setting up my camera alone in that desolate place, trembling with fear that a leopard would attack me."

Equipment: Nikon D5200 DSLR camera, Tokina 11–16mm lens, tripod **Exposure:** sky: ISO 3200 f/2.8, 100x 20"; foreground: ISO 800 f/5.6, 5x 5" **Software:** Sequator, PixInsight, Photoshop

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90 **Discover how the Celestron StarSense Explorer DX 130AZ comibines old and new**

HOW WE RATE

Each product we review is rated for performance in five categories. Here's what the ratings mean:

★★★★★ Outstanding ★★★★★ Very good
★★★★★ Good ★★★★★ Average ★★★★★ Poor/avoid

PLUS: Books on numbers large and small, the science of *Star Trek*, dark matter, and a roundup of the latest gear

@THESHED/PHOTOSTUDIO

Rainbow Astro RST-135 mount

A stylishly engineered, compact mount head with a huge load-bearing capacity

WORDS: TIM JARDINE

VITAL STATS

- **Price** £3,899
- **Mount type** Altaz/ equatorial
- **Type of gear** Strain wave gear (Harmonic Drive)
- **Load capacity** 13.5kg (18kg, with optional counter weights)
- **Autoguider port** ST4 port, or USB
- **Slew speed** 6° per second
- **Power input** 12V to 16V DC
- **Weight** 3.3kg
- **Supplier** First Light Optics
- **Email** questions@firstlightoptics.com
- **www.**firstlightoptics.com

At first glance you could be forgiven for thinking the diminutive RST-135 mount is another lightweight star-tracking accessory for cameras and small telescopes. As indicated by the price point, however, there is a lot more to this mount than meets the eye: it is an extremely capable modern machine that offers a comprehensive range of abilities to a dedicated amateur astronomer.

It is worth pointing out that the RST-135 is not an out-of-the box solution as a telescope mount, and some consideration needs to be given for suitable accessories. For instance, First Light Optics provided a Sightron carbon fibre tripod and an ADM Vixen-style saddle for the purposes of our review, but if we were buying the mount we would add a Rainbow Astro extension pier and a suitable 12–16V power supply to the package.

With the tripod securely attached to the mount head and the saddle bolted firmly in place, we attached our telescope, a 75mm refractor weighing around 3.5kg. The RST-135 can be operated as both a traditional altaz–style mount, or with simple adjustment it turns into an equatorial mount. We quickly discovered that we would not be able to just rely on our experience and set the mount and handset up without repeatedly referring to the extensive manual and user guide, which are available via download. There is also a handy additional guide available on the First Light Optics website (**www.firstlightoptics.com**), written by an end user, which is very helpful for explaining some of the quirks and features that are unique to the RST-135.

Put on the green light

We first configured the RST-135 in altaz mode, where the altitude of the mount is set to 90° by loosening a single hex bolt and the easy-to-operate altitude adjustment knobs. The hand controller displays which mode the mount is programmed for on the front screen. It seemed a shame, however, that this has a green light display, albeit dimmable, and that

ALL PHOTOS: @THESHED/PHOTOSTUDIO

the mount itself has a flashing yellow and green LED, as these quickly became a bright nuisance once our eyes were dark adapted. We would prefer to see muted red lights where lights are necessary. That aside, once the mount was positioned properly as per the manual, and an alignment tweak onto a known star was made via the manual azimuth adjusters, it was easy and accurate to use. It demonstrated a speedy slew speed without too much motor noise. We did a quick tour of some available Messier objects that were comfortably located within the view of our wide-field eyepiece.

Swapping to equatorial mode, after a rough manual polar alignment, we located six known stars, added them as alignment stars, and then proceeded ▸

Soft shell case

With portability being a key feature of the lightweight RST-135, it is supplied with a clamshell-style padded bag that holds the mount head securely and safely in an easily handled package. Being able to transport such capable equipment to dark or remote sites easily is very appealing.

TRIPOD NOT SUPPLIED WITH PRODUCT

Ports

Several ports are included with the RST-135. There is a standard ST4 auto-guider port, a USB, hand-controller ports and a power connector for a 12–16V DC power source, along with an on/off switch. Nearby LEDs show the operating state of the mount, although the green and yellow lights proved to be a little distracting during night operation.

Harmonic Drive – removing the need for counterweights

The mount is manufactured by an innovative Korean company called Rainbow Astro, which has taken the strain wave gear technology usually seen in robotics and applied it to telescope mounts. Along with a solid build-quality from a CNC-machined single block, these Harmonic Drive motors are accurate and precise, and enable the RST-135, which itself weighs only 3.3kg, to handle telescopes and equipment up to 13.5kg without the need for a counterweight.

This ability is a game changer for portable mounts, removing the need to lug heavy steel counterweights around. Some attention to the stability of the tripod and the positioning of the legs is still important, however, to avoid any imbalances or toppling. Should you need it, the option to add a counterweight bar and weights also remains, which adds further to the appeal of the RST-135 as a single-mount option for astronomers with a range of telescopes, as this has the effect of increasing the capacity of the mount to a hefty 18kg payload.

Built-in GPS and Wi-Fi

The RST-135 mount has a built-in GPS sensor that automatically provides the precise time, date, and latitude/longitude data to assist with accurate target location. With Wi-Fi mode enabled the mount can be controlled via a phone or tablet, connecting to apps like SkySafari that use the LX200 mount control protocol.

Hand controller

The RST-135 mount is managed by the Rugged Hubo-i SE hand controller with comprehensive star and object catalogues. It has backlit, chunky rubber-style buttons, and a direction pad that is easy to use with cold fingers. It also has a handy red-light torch on the rear.

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Altaz or equatorial mode

While the altaz setup might prove useful for grab and go astronomy, or daytime solar observing, the ability of the RST-135 to provide full equatorial tracking really opens up your options. Converting it to equatorial mode took us less than a minute, including the necessary on/off power cycle.

▸ to slew to a variety of objects. Note that accurate polar alignment can be carried out via the handset, or there is an attachment point for a PoleMaster camera. Our 13mm eyepiece provided an easygoing 40x magnification, and without fail the RST-135 put the desired object in the centre of the view. This accuracy gave us the confidence to try trickier objects that were not immediately visible without averted vision, or telescope tapping, although the mount and tripod were extremely stable and gently tapping the telescope had almost no effect. At one point we left the telescope pointing at the star Arcturus (Alpha (α) Boötis), went away for over an hour, and returned to find the object held perfectly central in the eyepiece, a testament to the mount's tracking accuracy.

Command and control

By controlling the RST-135 via its USB port and dedicated ASCOM driver (ASCOM is an industry-standard interface that allows different pieces of astronomical equipment to communicate), we found the mount integrated seamlessly with our planetarium software, allowing point and click Go-To options. We added a guide camera to the telescope, and the RST-135 was accurately auto-guided with the PHD2 telescope software for an extended period via the USB port, demonstrating that it would make an excellent candidate as a long-exposure astrophotography mount. The RST-135 can also create its own Wi-Fi network, although we were unable to test this due to an intermittent connection. First Light Optics was advised and it appears to be a one-off issue, with no other reports of such a problem by anyone else.

Overall, we feel that the novel RST-135 makes an exceptional portable mount, performing well for observers and astrophotographers alike.

VERDICT

Assembly	★★★★½
Build & design	★★★★★
Ease of use	★★★★½
Go-To accuracy	★★★★½
Stability	★★★★½
OVERALL	★★★★½

KIT TO ADD

1. Sightron Carbon Fibre Tripod

2. Suitable Vixen- or Losmandy-style saddle for attaching a telescope

3. Rainbow Astro Half Pier

FIRST LIGHT

Celestron StarSense Explorer DX 130AZ

5.1-inch Newtonian reflector

A manual telescope that can be easily aligned via an adaptor and free smartphone app

WORDS: JAMIE CARTER

VITAL STATS

- **Price** £479
- **Optics** 130mm (5.1-inch) Newtonian reflector
- **Focal length** 650mm, f/5
- **Mount** Altaz with slow-motion controls
- **App control** StarSense Explorer app with StarSense Sky Recognition technology and planetarium
- **Extras** StarSense dock for your smartphone, 25mm and 10mm eyepieces, StarPointer red dot finder
- **Weight** 8.1kg
- **Supplier** Celestron
- **Tel** 0118 467 1200
- **www.celestron.com**

Sometimes, computerised Go-To telescopes aren't all they're cracked up to be. Yes, they can automatically slew to an object in the night sky that otherwise a beginner would struggle to find, but such motorised scopes still need to be aligned with bright stars. For beginners, whose only way of navigating the night sky is by using a smartphone app, that can be tricky. So why not just use that app to align the telescope? That's the thinking behind Celestron's StarSense technology, which provides a free app and a carefully designed adaptor to fuse old and new techniques and create a novel way of exploring the night sky.

The DX 130AZ is a 5.1-inch (130mm) Newtonian reflector telescope that has a focal length of 650mm, giving a focal ratio of f/5, while the tube is 630mm long. It's mounted on a manual altaz 'Push-To' black aluminium tripod that proves this telescope's weak point. It's steady enough for the job once the spreader accessory tray is in place, but only just, and we did experience some vibrations after each movement. Since there's no motorised tracking mount, astrophotography is out of the question, save for a spot of afocal photography through the eyepiece. That, of course, requires a smartphone, which isn't going to be possible if you use this telescope as the maker intended you to (unless you have a spare phone). Although it's not essential to make the telescope usable, Celestron's StarSense Explorer app is at the core of how this combination works.

Upgrades

Also included with the DX 130AZ are two 1.25-inch eyepieces, 25mm and 10mm, which give 26x and 65x power, respectively. The supplied low-power eyepieces are nothing special and could easily be upgraded (a Barlow lens being the most obvious candidate), but they'll serve beginners well. A red dot finder is also provided if you want to ignore the app and aim the DX 130AZ completely manually.

Despite the StarSense app being relatively simple, it does take a little getting used to. For example, ▸

Dual-axis slow-motion controls

Slip clutches and geared slow-motion controls are provided in both axes to make it easy to fine-tune the field of view, and then follow it as it drifts through. These are easy to operate as you follow the app's directions to home in on your targets.

ALL PHOTOS: @THESHED/PHOTOSTUDIO

Accessory tray

Although most telescopes have one for placing eyepieces, here it's particularly useful because it can also hold a portable smartphone battery, so you can keep the StarSense app running for long periods. The tray doesn't feel particularly sturdy when it's being assembled, but it stayed in place all the time during our review.

Telescope

The telescope is a classical Newtonian reflector with a 130mm primary mirror with a focal length of 650mm, giving a focal ratio of f/5. It is supplied with 25mm and 10mm 1.25 inch-fit eyepieces, a red dot finder and an altaz manual mount.

FIRST LIGHT

Cable management

Relying on an app for celestial navigation is useful, but using StarSense during a long observing session can drain a smartphone's battery. We're impressed that Celestron has left a gap in the foot of the smartphone clamp to trail a cable to a portable battery, which can easily sit on the accessory tray.

An app for easy target location

Contrary to what Celestron's marketing campaign may have you believe, the Explorer DX 130AZ won't magically use your smartphone to align itself to the night sky. In reality, it's a little more manual than that. On the other side of the mounting arm to the telescope is the StarSense smartphone adaptor dock. With the free StarSense Explorer app downloaded from Google Play or the Apple App Store, you simply insert your smartphone into the holder and align its camera with the mirror underneath. It then uses its StarSense sky recognition technology to match what your smartphone's camera sees on the mirror with its planetarium database. The app then gives you on-screen arrows and targets to lead you to your chosen object, as you manually move the telescope, virtually zooming in the closer you get and changing those arrows and targets from red to green. You then take your hands off the telescope and look through the eyepiece and you should see your target. If you don't, there are two slow-motion controls for fine-tuning its position.

©THESHED/PHOTOSTUDIO X 4

Universal smartphone holder

Fitted with a spring-loaded tab, any size of smartphone is kept snug in this simple yet strong device beside the mount. Behind it are two left/right and up/down knobs to align the smartphone's camera with the 35mm x 70mm mirror just above and behind.

▸ when you first begin your session, it asks you to point the telescope towards a clear patch of sky with stars, and to wait until the red bullseye on the screen turns yellow. Then you simply follow the directions to your target, wait for it to turn green, and look through the eyepiece. The trouble is, if you use the app's red-light mode, which you should if you want to preserve your night vision, those colours obviously disappear. We also had trouble aligning the telescope during the bright nights between a first quarter Moon and a full Moon.

Impressive views

Manually aimed at the terminator across the lunar surface we were immediately delighted by the twin-knobbed, low-gear focusing control, which is grooved, rubberised and easy to operate with gloved hands in the cold. It quickly produced sharp, precise and contrast-rich views of the crater-crowded southern highlands. The StarSense app's lists of 'tonight's best objects', which are each labelled 'City Viewable' or 'Dark Sky Viewable', help to keep expectations in check for those in light-polluted urban areas.

Used under moonless skies, the DX 130AZ impressed us with its clear and crisp low-power views of deep-sky sights, including the Orion Nebula, M42, and the M35 open cluster in Gemini. However, we did find that the tripod itself got in the way of us aiming the DX 130AZ at anything remotely close to the zenith.

It may be an all-new way of aligning and using a telescope, but the StarSense app does have one hangover from the handsets provided with most Go-To telescopes, which is audio. With spoken-word descriptions of hundreds of objects, and a great deal of advice on how and when to observe each object, the StarSense app – together with the DX 130AZ telescope it aids – produce a delightfully old-school package of smartphone app and manual telescope. This cleverly unites the old and new and keeps the asking price relatively low.

VERDICT

Assembly	★★★½☆
Build & Design	★★★★☆
Ease of use	★★★★☆
Features	★★★☆☆
Optics	★★★★½
OVERALL	★★★★☆

KIT TO ADD

1. Celestron Omni 2x Barlow lens, 1.25-inch

2. Portable smartphone battery

3. Bluetooth earphones to hear in-app audio

BOOKS

Fantastic Numbers and Where to Find Them

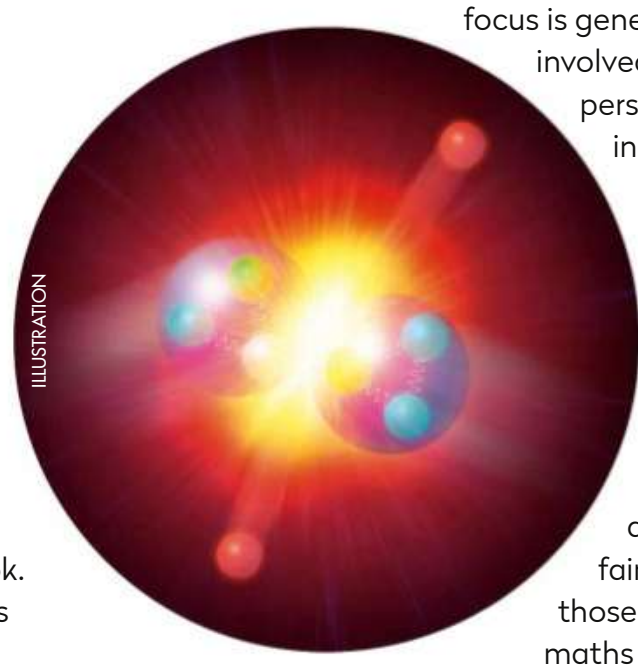
Antonio Padilla
Allen Lane
£25 ● HB

The title *Fantastic Numbers and Where to Find Them* might imply that this is a maths book, but that's not true. It's actually part maths, part physics and part history book. While the narrative is dictated broadly by numbers, the content is mostly about cosmology and particle physics. Beginning with large numbers, then moving to small numbers, and finally back to infinity, the topics flip around between chapters. But for the reader, this all adds to the variety.

The book is not an easy read. You need to keep your wits about you, as it is packed with information, whether that's the history of the zero, an analogy about spacetime or the story of particle physics. It's all introduced in a way that's intended to be accessible and, providing you pay attention, generally hits the mark. Unless you're a theoretical physicist, there will be bits that will make your head hurt to think about, but that's partly the point.

There are times when the narrative of numbers seems to get forgotten in the interest of exploring physics. In chapter 0.0000000000000001 there's a few dozen pages during which we explore bosons, leptons, quarks, gauge theory, Feynman diagrams, quantum chromodynamics and supersymmetry, and the Higgs boson. It's a lot to take in, but it's broken up with some helpful and often entertaining analogies, along with clear diagrams, sometimes involving wine bottles and Rapunzel in space (though not at the same time!).

As well as the analogies, there's also some interesting history to be found. Whether that's the history of maths or physics and cosmology, the historical focus is generally on the people involved. Some of their personal lives are incredibly tragic, but this helps bring the history to life. Pleasingly, the book is not too western-focused, as many accounts often are.



ILLUSTRATION

▲ **A Higgs boson particle, produced by two colliding protons**

MARK GARLICK/SCIENCE PHOTO LIBRARY/ALAMY STOCK PHOTO

It may be dense and not for the faint-hearted, but for those with an interest in maths and/or physics, there's an awful lot of interesting content here. And, since it barely scratches the surface of some topics, it might just persuade some people to become theoretical physicists themselves. ★★★★☆

***Dr Chris North** is Head of Public Engagement in Physics and Astronomy at Cardiff University*

Interview with the author
Antonio Padilla

What's your favourite number?

Zero. Medieval thinkers saw the devil in zero, in the absence of God, but it's the most beautiful number of all, an avatar for the symmetries that underpin the clockwork of our Universe. When something vanishes – when there is a zero – there is always symmetry at play. Take the photon, a particle of light travelling at the cosmic speed limit. It can only do this because it has a zero – a vanishing mass guaranteed by the elegant symmetries of electromagnetism. You will never catch a photon and you will never find a number more beautiful than zero.

Is there a smallest number or a biggest number?

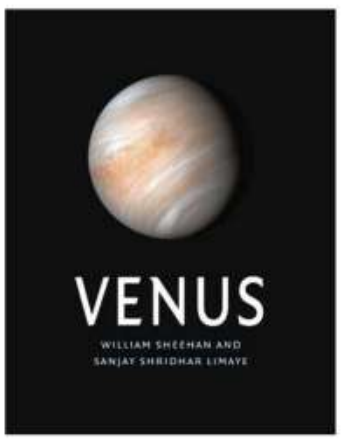
Very small and very big numbers are, in a way, one and the same. If I have a very big number, like a googol, I can also find a very small number just by taking its reciprocal. The mathematics of infinitesimals is really the mathematics of infinity. Our quest to understand nature on the smallest scales is to conquer the infinities that plague our calculations. Some infinities have been conquered, but the infinities of gravity remain untamed.

With gravity, we cannot think about the fabric of space over distances shorter than the Planck length (a universal set of units for length, time, mass, temperature and other physical qualities devised by Max Planck in 1899) – about 10^{-35} metres. This is the shortest meaningful distance in nature. The distance to the edge of the visible Universe is about 10^{61} times larger, so in a way, that is the biggest number, at least in our Universe. And 10^{-61} is the smallest.

***Antonio Padilla** is a theoretical physicist and cosmologist at the University of Nottingham*

Venus

William Sheehan, Sanjay Shridhar Limaye
Reaktion
£25 ● HB



What can we learn about our own planet's origins – and possible fate – by studying its sister Venus? The two planets are similar in size and composition, and yet have evolved differently. This short but thorough book is a chronological assessment of what we know about Venus, from its importance as the 'Queen of Heaven' in ancient Babylon to the latest tantalising detection of phosphine and possible evidence of life.

Paradoxically, Venus's extreme brilliance (it can even be observed during the day) has also made it very difficult to study. Not until the 1970s and the Soviet Venera missions did we get decent images of the planet's surface underneath its thick atmosphere of carbon dioxide. Studies of Venus are not just important in their own right but have also contributed to other aspects of astronomy: the authors explain clearly how Galileo's observations of the planet's phases provided crucial support for the heliocentric model, and how its transit across the Sun enabled 18th-century astronomers to measure the radius of Earth's orbit for the first time.

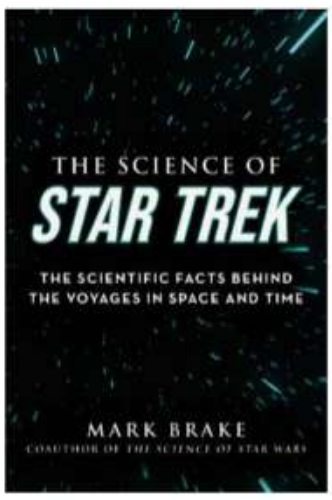
It's well-written and Illustrations of Venus from ancient times to modern day make this visually appealing. The authors cover a huge amount of science, perhaps straying a bit too far from their brief in discussing evidence for a greenhouse effect on Earth, as well as post-WWII rocketry. All in all, It's a worthy addition to Reaktion's science 'Kosmos' series. ★★★★★

***Pippa Goldschmidt** is a science and astronomy writer*

The Science of Star Trek

SCI-FI SCIENCE

Mark Brake
Skyhorse Publishing
£10.99 ● PB



Sometimes, considering the science behind a beloved science fiction world takes a little of the magic out of the story, placing it back within the mundane. But here Mark Brake boldly goes where none have gone before and explains the science behind the *Star Trek* franchise in a way that adds to the wonder of the Universe, rather than detracting from it.

The Science of Star Trek explores one of the best known and most loved science fiction universes in incredible detail, covering a huge range of topics in short, snappy chapters. The author explains the science behind space travel, exoplanet exploration, cyborgs and much more with an authoratitive voice in an easily digestible format. The stand-out feature of this book is how it covers not just the ways in which *Star Trek* was influenced by science, but the ways in which science itself has been influenced by *Star Trek*.

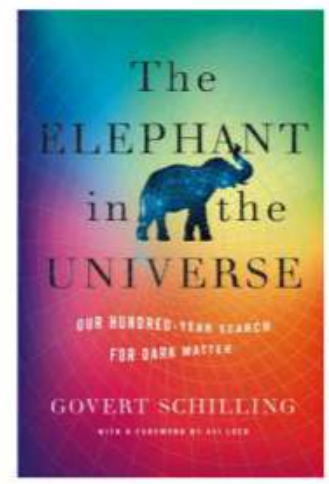
Brake discusses how our own space culture has been impacted by *Star Trek*, with its sci-fi inventions that might be less fiction than we expect, and what the series can teach us about the political science of war. Each chapter is concise and to the point, prefaced by quotes, and Brake's voice is warm and witty. He gives an uplifting view of what humanity might be able to achieve in the future, provided we learn the right lessons.

Perfect for any fan of the franchise, *The Science of Star Trek* is a fascinating and insightful read. ★★★★★

***Katie Sawers** is a science writer specialising in cosmology and the history of astronomy*

Elephant In The Universe

Govert Schilling
Harvard University Press
£23.95 ● HB



The 'elephant' in this particular book is dark matter – the enigmatic constituent accounting for 85 per cent of matter in the Universe.

Giving a thoroughly up-to-date history of the emergence of cold dark matter (CDM) cosmology, the author covers the work of Kapteyn, Oort and Zwicky, and Rubin's discovery of flat galaxy rotation curves. Thankfully, the book also redresses the often overlooked work of radio astronomers: notably Roberts, Bosma and Shostak. Armed with this good grounding in the background physics, and its development, we next join the hunt for the nature of the invisible beast.

Rather than a dry, terse recounting of scientific fact, Schilling has chosen to play out the adventure of discovery with an emphasis on the characters of those involved. Based on numerous interviews and discussions with scientists in the field, the book is both an advertisement for the thrill of scientific discovery and the visionaries who pursue the big questions simply because they are there. Schilling has craftily combined his lucid and accessible descriptions of science with the personal story of those unlocking the finer details of the missing mass mystery. The result is enthralling.

Sometime in the future, maybe this year, maybe a century or more hence, someone is going to write the final chapter of this story. But even without that final revelation, this scientific 'whodunit', with its diverse cast of characters, false leads and enticing clues, is still a captivating scientific thriller. Future generations will no doubt be grateful for this fascinating contemporary account. ★★★★★

***Alastair Gunn** is a radio astronomer based at Jodrell Bank, Cheshire*

Ezzy Pearson rounds up the latest astronomical accessories

GEAR

1 Omegon Pro Kolossus mount

Price £520 • **Supplier** Astroshop.eu • **www.astroshop.eu**

ADVANCED Large binoculars give amazing views of the night sky, but holding them can be tiring. This parallelogram mount supports larger binoculars, like 20x80s and 25x100s, and its three-part swivel arm with 360˚ rotation means you can move it to observe any area of the sky.

2 Thermos King Food Flask

Price £28 • **Supplier** Argos • **www.argos.co.uk**

On long, cold nights at the eyepiece a hot meal can stave off the chill. This 710ml flask can hold enough soup or pasta to last the night, and its wide opening makes it ideal for food. The lid doubles as a bowl.

3 Sky-Watcher SmartPhoto Plus smartphone camera adaptor

Price £24.95 • **Supplier** Harrison Telescopes • **Tel** 01322 403407 • **www.harrisontelescopes.co.uk**

This adaptor transforms your smartphone into an astro camera, by helping you line it up at the eyepiece. The unique clamping system helps to centre the camera in the eyepiece with ease, while the foam-lined jaws will hold your phone securely.

4 Kidz Labs Create A Night Sky

Price £15.99 • **Supplier** Waterstones • **www.waterstones.com**

Want to learn about the stars and have a fun, practical project? This kit comes with all the pieces needed to create a globe showing the stars of the Northern and Southern Hemispheres. A great STEM activity, it leaves you with a beautiful lighting piece.

5 Celestron USB Cooling Fan for Dobsonian Telescopes

Price £24.99 • **Supplier** The Widescreen Centre • **www.widescreen-centre.co.uk**

This fan helps circulate the air around your Dobsonian telescope tube so it can reach ambient temperature, which prevents turbulent air from blurring your image. It can be connected to any USB power source.

6 Beelink GKMini PC

Price £219 • **Supplier** First Light Optics • **www.firstlightoptics.com**

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Melissa Brobby interviews Dr Iain McDonald

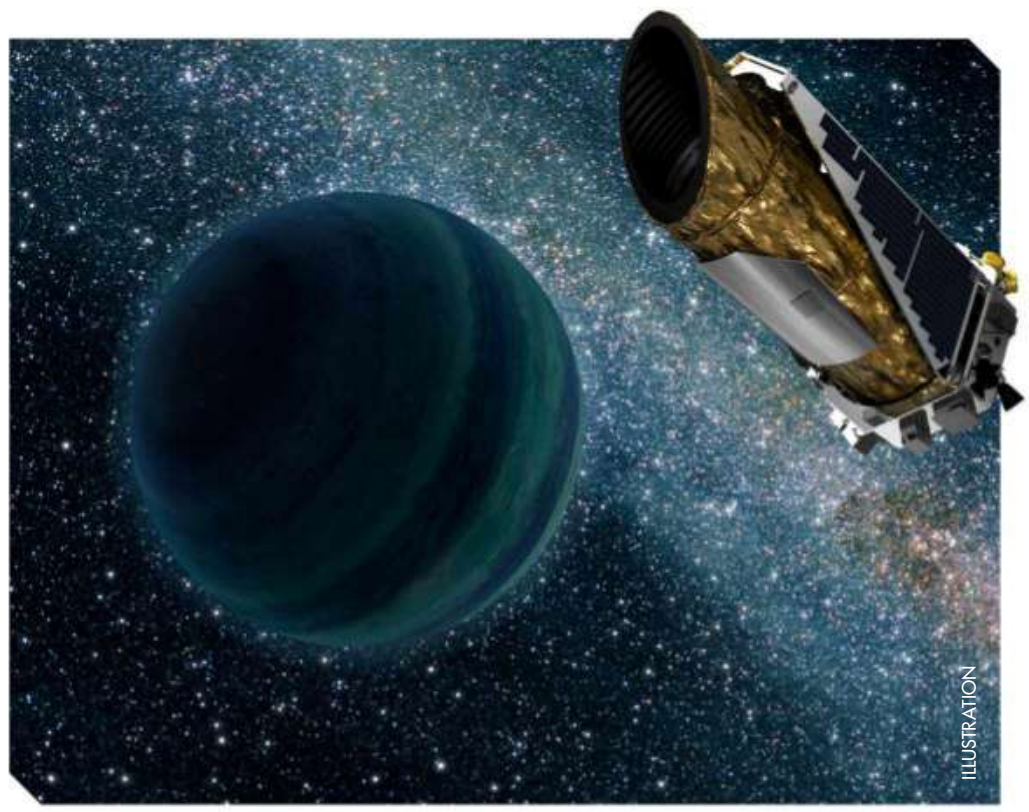
Q&A WITH A PLANET HUNTER

The Kepler space telescope was retired in 2018 but its data is still revealing planetary candidates, including free–floating worlds

What is microlensing and how many planetary candidates have been found in data from the Kepler space telescope using the method?
We found five planetary candidates via microlensing, which works by waiting until the planets pass in front of a background star. Einstein's theory of relativity states that light from the background star should be bent around the planet, which acts as a lens, making the background star brighter for a short time. This length of time depends on the mass of the lens and how fast it is moving, and for planets this is only a few hours. Sadly, microlensing events are one-time-only, meaning we might struggle to take more data of these planetary candidates.

At this stage, can the composition and masses of these planetary candidates be determined?
We don't know much about these planetary candidates, but we're collecting together old data from Earth-bound observatories that was taken at the same time. Differences in the time and strength of the brightening on Earth can help us separate the mass of the lens from its speed, and also prove these aren't just normal stars that are getting brighter of their own accord. Based on the short timescales of their brightening, though, we expect these planets to be about the same mass as Jupiter or smaller. Unfortunately, we can't say anything about their compositions.

As Kepler was not designed to find planets using microlensing, how difficult was it to find these signals using data from the space telescope?
Kepler was very useful because it was able to stare at a fairly large part of the sky continuously. It was pointed at the most star-rich parts of the Galaxy, where there can be dozens of stars in every pixel. However, many of these stars are variable and undergo brightening events of their own accord, and passing asteroids keep getting in the way. The fact that the spacecraft kept drifting off course, because one of its stabilising wheels was broken, didn't help either! That meant it took four years for us to weed out the planetary candidates we wanted from the data, and be convinced that the stars weren't getting brighter for some other reason.



ILLUSTRATION

▲ Kepler (inset) found hundreds of planets during its primary missions; now its data has also revealed free-floating worlds

Do we know if these planetary candidates have host stars?
Stars should produce their own, much stronger and longer microlensing signals, which should be visible in the light-curves too. One of our planetary candidates appears to be a Jupiter-like planet going around a star. The other four candidates we found don't show a star-like signal to go with the planetary signal. That could be because they are orbiting very far from their host stars, but is more likely to be because they are floating freely in space.

Is there a theory to explain how some of these planetary candidates came to be free-floating?
We think free-floating planets form when planetary systems are disrupted. If one planet comes too close to another, one can be thrown towards its star (maybe making a 'hot Jupiter') and the other one gets thrown out of the system, becoming free-floating. By studying these free-floating planets, we can look at how stable planetary systems are.

What impact could the use of microlensing have on exoplanet-hunting?
Most exoplanet-hunting techniques either find planets really close into their star (like the transit and radial-velocity methods), or very big, young planets far away from their star (the direct-imaging method). Microlensing is really helpful for catching the planets in the middle – planets that are similar to our own Jupiter – and smaller planets much further out, including free-floating ones. It's even quite effective at detecting Earth-like planets. Other methods require many years to detect such planets. Instead, microlensing relies on the blind luck of the planet passing in front of a star.

Dr Iain McDonald is a Research Fellow in Astrophysics at the University of Manchester, whose field of research is in the discovery and characterisation of exoplanets

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THE SOUTHERN HEMISPHERE

With Glenn Dawes

Catch five planets close to the Moon, and discover the Ink Spot, a deep-sky treasure in Sagittarius

When to use this chart

1 July at 00:00 AEST (14:00 UT)
15 July at 23:00 AEST (13:00 UT)
31 July at 22:00 AEST (12:00 UT)

The chart accurately matches the sky on the dates and times shown for Sydney, Australia. The sky is different at other times as the stars crossing it set four minutes earlier each night.

JULY HIGHLIGHTS

This month all five naked-eye planets can be seen close to the Moon. In the early evening of 15th, the full Moon is 6° from Saturn. Then as the Moon's phase wanes, it visits Jupiter separated by 5° on the morning of the 19th. Next up, three days later, the last quarter Moon is only 3° from Mars. On the 26th, having now slipped into the dawn glow, its thin crescent is 8° from brilliant Venus. Finally, after new Moon on the 30th the two-day old Moon is 5° from Mercury.

STARS AND CONSTELLATIONS

The most southerly zodiacal constellations are high in July's evening sky. The easily recognised constellations of Sagittarius (with its Teapot asterism) and Scorpius, the Scorpion, also coincide with the Milky Way's centre. The two flanking constellations are identifiable under dark skies, with the 'smile' of Capricornus to the east and kite-shaped Libra to the west. You can also view the dark and bright lanes (nebulae) that make up our Galaxy's 'hub'.

THE PLANETS

View Saturn in the eastern evening sky, rising around 20:00 mid-month. Located in Capricornus, it stands out in a barren part of the sky, with only the star Fomalhaut rivalling its brightness. Neptune follows two hours later, while Jupiter joins the show, rising about 23:00. The early morning sees Mars and Uranus arriving and converging: they close July only 2° apart. Venus continues to drop towards the Sun, and this month is the last time we see it outside dawn's glow.

DEEP-SKY OBJECTS

Let's take a trip into Sagittarius, the Archer. Starting at the 'spout' star of the Teapot, Gamma² (γ²) Sagittarii, moving north you'll pass through a Milky Way region full of stars. When you have gone 2° you will encounter a distinctive dark nebula, Barnard 86 (RA = 18hr 02.9m, dec. = -27° 52'). It has a high extinction level, hence its nickname, the Ink Spot. The nebula is 6 arcminutes across, which tapers to a point at the northern end, with a mag. +6.6 star on the western edge.

Eastwards of this 'Spot', in the same eyepiece field, is open cluster NGC 6520, which consists of around two-dozen faint stars scattered over 2 arcminutes, just north of a pair of brighter stars.

Sagittarius is home to numerous globular clusters and there are two conveniently close to the 'spot', NGC 6540 is 0.7° eastwards and the fainter Djorgovski 2 is only 0.2° westwards.

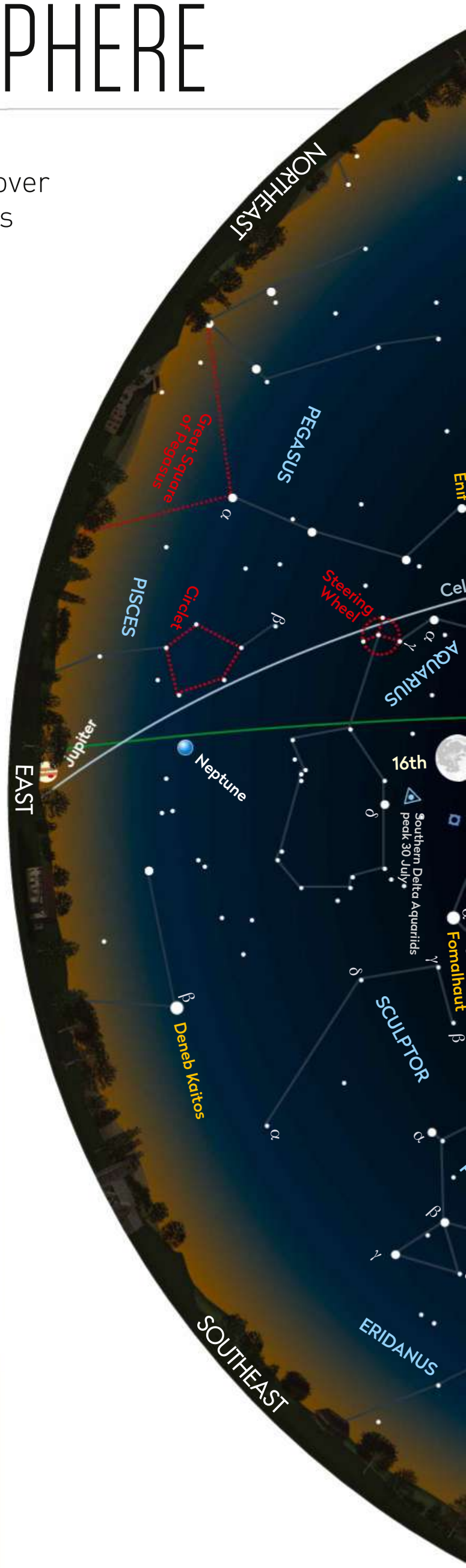

Chart key

- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- COMET TRACK
- ASTEROID TRACK
- METEOR RADIANT
- QUASAR
- PLANET

STAR BRIGHTNESS:
- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER

CHART: PETE LAWRENCE

NORTH
NORTHWEST
WEST
SOUTHWEST
SOUTH
DRACO
HERCULES
M92
Keystone
M13
CORONA BOREALIS
BOÖTES
Arcturus
Kite
Denab
Summer Triangle
LYRA
Vega
CYGNUS
M29
Northern Cross
Albireo
M57
Veil Nebula
VULPECULA
M27
M71
Collinder 399
DELPHINUS
SAGITTA
Altair
AQUILA
EQUULEUS
M15
Rasalhague
Rasalgethi
IC 4665
SERPENS CAPUT
OPHIUCHUS
SERPENS CAUDA
M14
M12
M10
M5
Coffin
M11
SCUTUM
M17
M107
M2
NGC 7009
Alpha Capricornids peak 30 July
Ecliptic
Saturn
M75
Pluto
NGC 6540
M25
M8
M9
M22
NGC 6520
Djorgbwski 2
M19
M62
M55
13th
Teapot
B86
M7
M6
Antares
10th
LIBRA
VIRGO
HN 28
7th
Spica
CAPRICORNUS
M30
MICROSCOPIUM
Piscis Austrinids peak 28 July
SAGITTARIUS
CORONA AUSTRALIS
SCORPIUS
NORMA
ARA
LUPUS
PISCIS AUSTRINUS
GRUS
INDUS
PAVO
TRIANGULUM AUSTRALE
CORVUS
HYDRA
M68
CIRCINUS
Rigel Kentaurus
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CENTAURUS
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IC 2944
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NGC 3532
Southern Pleiades
CARINA
Eta Carina Neb
VELA
Achernar
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CHAMAELEON
MENSA
Miaplacidus
RETICULUM
NGC 2070
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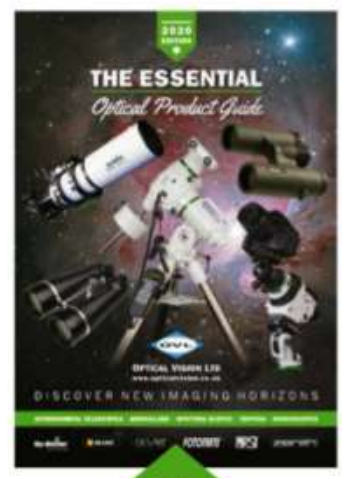

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